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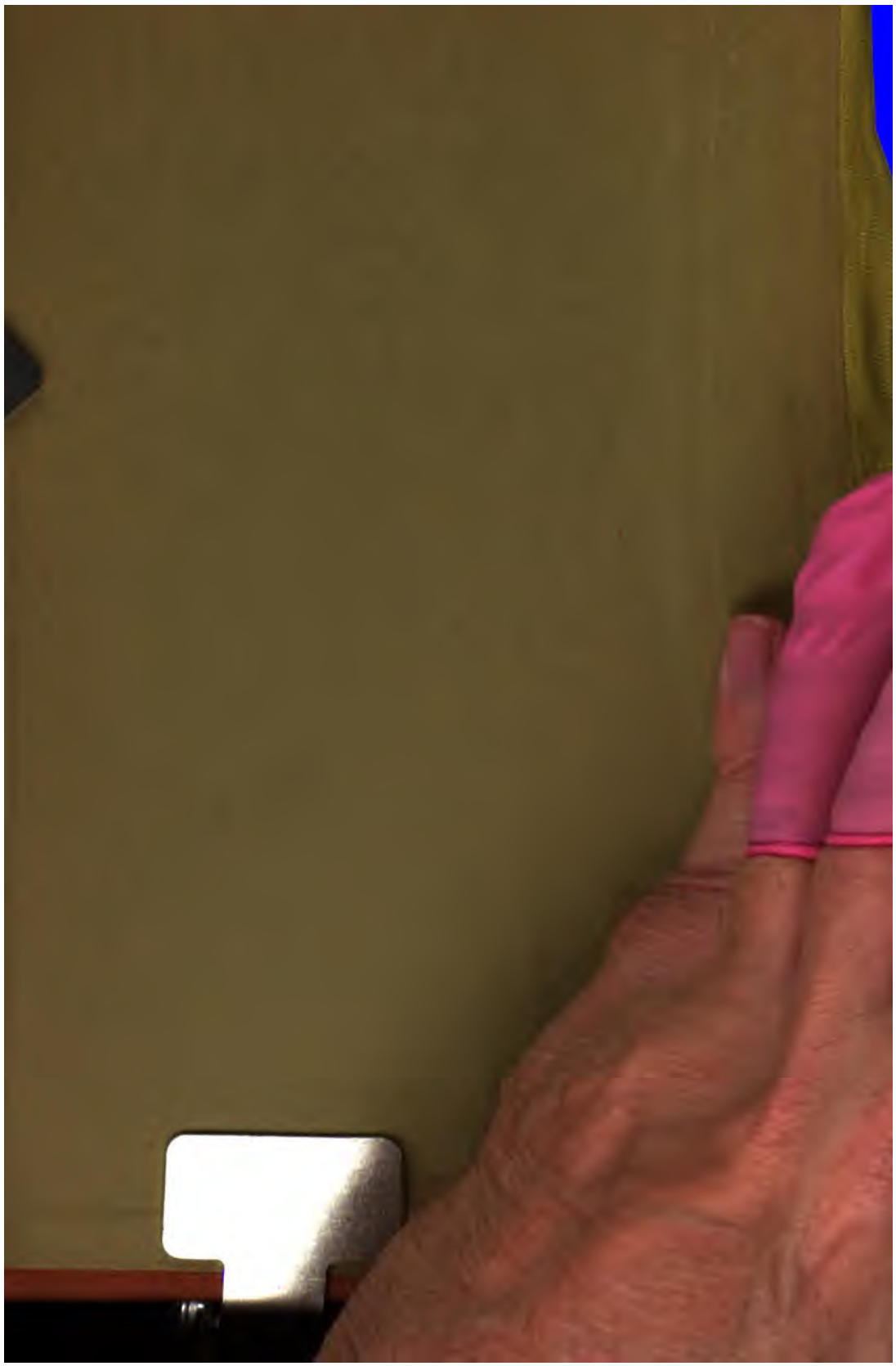

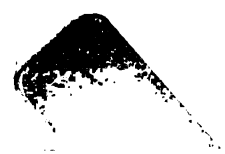

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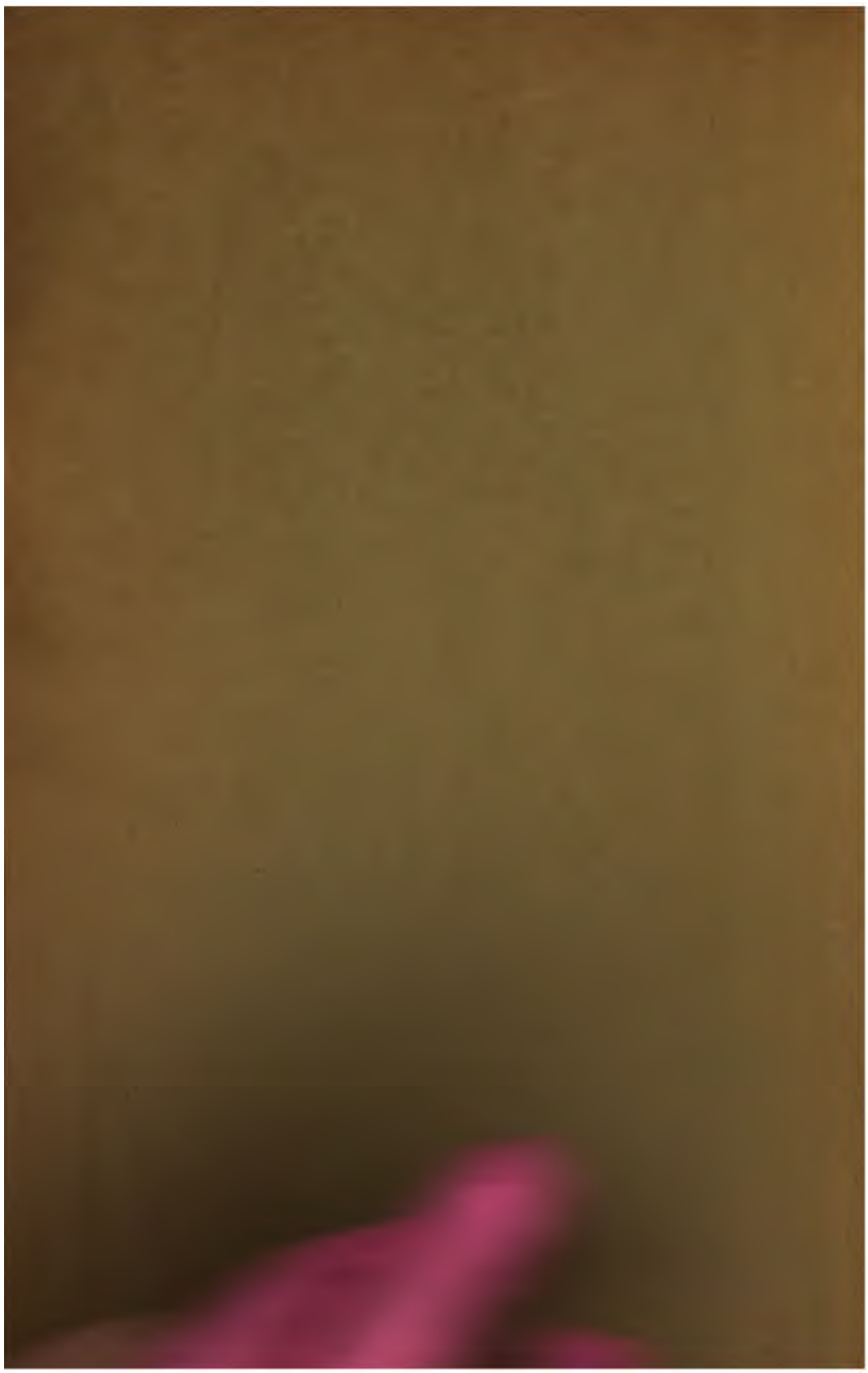

THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY AND TRADE

DURING

1913

FOUNDED BY RICHARD P. ROTHWELL

EDITED BY

G. A. ROUSH, A.B., M.S.

ASSISTANT PROFESSOR, DEPARTMENT OF METALLURGY, LEHIGH UNIVERSITY,
ASSISTANT SECRETARY OF THE AMERICAN ELECTROCHEMICAL SOCIETY

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LIST OF CONTRIBUTORS

ABELL, O. J.
Western Editor, *Iron Age*, 1507 Otis Bldg., Chicago, Ill.
Chicago Iron Markets.

ADDICKS, LAWRENCE
Douglas, Ariz.
Electrolytic Copper Refining.

ALLEN, R. C.
State Geologist, Lansing, Mich.
Salt in Michigan.
Pyrite in Michigan.

ASTON, JAMES
Assistant Professor of Metallurgy, University of Cincinnati, Cincinnati, O.
Manganese.
Molybdenum.
Nickel and Cobalt.
Titanium.

AUSTIN, L. S.
Consulting Metallurgical Engineer, Salt Lake City.
Metallurgy of Copper.

BAGLEY, JAMES
State Mine Inspector, Seattle, Wash.
Coal in Washington.

BAIN, H. FOSTER
Editor, *Mining and Scientific Press*, San Francisco, Calif.
Potassium Salts.

BARTLETT, R. L.
Instructor in Mining, Lehigh University, South Bethlehem, Pa.
Zinc.

BERKEY, C. P.
Instructor in Geology, Columbia University, New York City.
Corundum and Emery.

BLACKER, GEO.
Inspector of Coal Mines, District No. 1, Cumberland, Wyo.
Coal in Wyoming.

BLATCH
Geolog
Ge
State

BLISS, J. W.
State Engineer, Bismarck, N. D.
Coal in North Dakota.

BOECK, P. A.
Kieselguhr Co. of America, 1106 Van Nuys Bldg., Los Angeles, Cal.
Diatomaceous Earth.

BOLT, MARTIN
Chief Clerk, Ill. State Min. Board, Springfield, Ill.
Coal in Illinois.

BOWNOCKER, J. A.
State Geologist, Columbus, O.
Petroleum in Ohio.
Natural Gas in Ohio.

BOYLE, EDWARD
Chief Mine Inspector, McAlester, Okla.
Coal in Oklahoma.

BUCK, C. A.
President, Bethlehem Chile Iron Mines Co., South Bethlehem, Pa.
Iron Ore in Chile.

BUNTING, J. W.
Box 872, Norfolk, Va.
Hampton Roads Coal Market.

CAETANI, GELASIO
Mining Engineer, Crocker Bldg., San Francisco, Calif.
Analysis of Smelter Contracts.

CALLEN, A. S.
Assistant in Metallurgy, Lehigh University, South Bethlehem, Pa.
Selenium and Tellurium.

CHAMBERLAIN, JOHN W.
90 Johnson Park, Buffalo, N. Y.
Buffalo C l Market.

CHANNING, J RKE
President, Mia Company.
Copper t the Mi i.

COH , H.
Mini
C

DEMING, H. C.
Geologist, Harrisburg, Pa.
Pyrite in Pennsylvania.

DENNIS, CLIFFORD G.
Mining Engineer, Crocker Bldg., San Francisco, Cal.
Quicksilver.

FICHTEL, CARL L. C.
Electrical Department, Calumet and Hecla Mining Co., Calumet, Mich.
Copper in Michigan.

FINK, C. G.
Research Chemist, General Electric Co., Harrison, N. J.
Tungsten.

FISCHER, SIEGFRIED
Instructor in Metallurgy, Lehigh University, South Bethlehem, Pa.
Radium.
Uranium and Vanadium.

FULTON, CHARLES H.
Professor of Metallurgy, Case School of Applied Science, Cleveland, O.
Gold and Silver Milling.

GARRISON, F. LYNWOOD
Mining Engineer, 982 Drexel Bldg., Philadelphia, Pa.
Platinum.

GEORGE, R. D.
Director, State Geological Survey, Boulder, Colo.
Gypsum in Colorado.
Petroleum in Colorado.

GORDON, C. H.
Associate State Geologist, University of Tenn., Knoxville, Tenn.
Bauxite.

HALL, FRANK
Deputy to the Chief Mine Inspector, Pennsylvania. Dept. of Mines, Harrisburg, Pa.
Coal in Pennsylvania.

HAMILTON, F. McN.
State Mineralogist, San Francisco, Calif.
Pyrite in California.

HICE, RICHARD R.
State Geologist, Harrisburg, Pa.
Petroleum in Pennsylvania.
Natural Gas in Pennsylvania.
Salt in Pennsylvania.

HILL, GEO.
Chief Inspector of Mines, Jefferson, Mo.
Coal in Missouri.

HINTZE, F. F., JR.
Assistant Professor of Geology, Lehigh University, South Bethlehem, Pa.
Copper.

HOFMAN, H. O.
Professor of Metallurgy, Massachusetts Institute of Technology, Boston, Mass.
Recent Improvements in Lead Smelting.

HUNTLEY, L. G.
Petroleum Engineer, Associated Geological Engineers, 331 Fourth Ave., Pittsburg, Pa.
Petroleum in Mexico.

HUTCHINS, JOHN POWER
Consulting Mining Engineer, St. Petersburg, Russia, and London, England.
Copper in Russia.
Gold in Russia.
Platinum in Russia.

INGALLS, W. R.
Editor, *Engineering and Mining Journal*, New York, N. Y.
Metallurgy of Zinc.

JUDD, EDWARD K.
Instructor in Mining, School of Mines, Columbia University, New York, N. Y.
Asbestos.
Magnesite.
Mica.
Tin.

KANARY, THOMAS
State Inspector of Coal Mines, St. Charles, Mich.
Coal in Michigan.

KEEGAN, FRANCIS

KENNEDY, J. E.
Platteville, Wis.
Zinc in Wisconsin.

KÜMMEL, H. B.
State Geologist, Trenton, N. J.
Glass Sand.

KUNZ, GEO. F.
Gem Expert, Tiffany & Co., New York, N. Y.
Precious Stones.
International Carat.

LANDES, HENRY
State Geologist, Seattle, Wash.
Gypsum in Washington.

LEHMAN, J. W.
60 Ruggery Bldg., Columbus, O.
Ohio Coal Market.

LESLEY, ROBERT W.
611 Pennsylvania Bldg., Philadelphia, Pa.
Cement.

LESLIE, E. H.
Assistant Editor, *Mining and Scientific Press*, San Francisco, Cal.
Gold and Silver in Mexico.

LOCKE, CHARLES E.
Professor of Mining, Massachusetts Institute of Technology, Boston, Mass.
Ore Dressing and Coal Washing in 1912.

LUTY, B. E. V.
Correspondent for the *Engineering and Mining Journal*, Pittsburgh, Pa.
Pittsburgh Coal Market.
Pittsburgh Iron and Steel Markets

MCDERMOTT, J. B.
State Coal Mine Inspector, Helena, Mont.
Coal in Montana.

MAGUIRE, C. H.
Instructor in Chemistry, Lehigh University South Bethlehem, Pa.
Bismuth.
Bromine and Iodine.
Cadmium.
Chromium.

MATTESON, W. G.
Instructor in Geology, Lehigh University, South Bethlehem, Pa.
Petroleum and Natural Gas.

MILLER, BENJAMIN L.
Professor of Geology, Lehigh University, South Bethlehem, Pa.
Graphite.

NEWLAND, D. H.
Assistant State Geologist, Albany, N. Y.
Garnet.
Gypsum in New York.
Salt in New York.

NORWOOD, C. J.
Chief Mine Inspector, Lexington, Ky.
Coal in Kentucky.

PEARCE, FRANK I.
Deputy Inspector of Mines and Mining, Indianapolis, Ind.
Coal in Indiana.

PECK, FREDERICK B.
Professor of Geology and Mineralogy, Lafayette College, Easton, Pa.
Talc and Soapstone.

PETTIT, J. E.
State Mine Inspector, Salt Lake City, Utah.
Coal in Utah.

REED, A. H.
Marion Ky.
Barytes.
Fluorspar.

READ, T. T.
Associate Editor, *Mining and Scientific Press*, New York City.
Antimony in China.
Coal in China.
Copper in China.
Hydrometallurgy of Copper.
Iron and Steel in China.
Lead in China.
Zinc in China.

RICHARDS, J. W.
Professor of Metallurgy, Lehigh University, South Bethlehem, Pa.
Aluminium.

RICHARDS, ROBERT H.
Professor of Mining and Metallurgy, Massachusetts Institute of Technology, Boston, Mass.
Ore Dressing and Coal Washing in 1912.

SALISBURY, SAMUEL H., JR.
Assistant Professor of Industrial Chemistry, Lehigh University, South Bethlehem, Pa.
Sodium and Sodium Salts.
Sulphur, Pyrite and Sulphuric Acid.

SHANNON, C. W.
State Geologist, Norman, Okla.
Gypsum in Oklahoma.

VALUE OF FOREIGN COINS

ESTIMATE BY DIRECTOR OF THE MINT, 1914.

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins.
Argentine Republic.	Gold...	Peso	$0.9647	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions.
Austria-Hungary..	Gold...	Crown	.203	Gold: 10 and 20 crowns. Silver, 1 and 5 crowns.
Belgium	Gold...	Franc	.193	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Gold...	Boliviano	.389	Silver: boliviano and divisions.
Brazil	Gold...	Milreis	.546	Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis.
British Possessions, N. A.	Gold...	Dollar	1.000	.....
Central Amer. States—Costa Rica.	Gold...	Colon	.465	Gold: 2, 5, 10 and 20 colons ($9.307) Silver: 5, 10, 25 and 50 centimos.
British Honduras.	Gold...	Dollar	1.000	.....
Nicaragua	Gold ..	Cordova	1.000	.....
Guatemala, Honduras, Salvador	Silver .	Peso	.422	Silver: peso and divisions.
Chile	Gold...	Peso	.365	Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions.
China	Silver	Tael.. Amoy	.692	.....
		Canton	.690	.....
		Cheefoo	.661	.....
		Chin Kiang	.676	.....
		Fuchau	.640	.....
		Haikwan (customs).	.704	.....
		Hankow	.647	.....
		Kiaochow	.670	.....
		Nankin	.685	.....
		Niuchwang	.649	.....
		Ningpo	.665	.....
		Peking	.674	.....
		Shanghai	.632	.....
		Swatow	.639	.....
		Takau	.696	.....
		Tientsin	.670	.....
		Dollar Yuan	.504	.....
		Dollar Hongkong	.455	.....
		Dollar British	.455	.....
		Dollar Mexican	.458	.....
Colombia	Gold...	Dollar	1.000	Gold: condor ($9.647) and double condor. Silver: peso.
Denmark	Gold...	Crown	.268	Gold: 10 and 20 crowns.
Ecuador	Gold...	Sucre	.487	Gold: 10 sucres ($4.8665). Silver: sucre and divisions.
Egypt	Gold...	Pound (100 piasters)	4.943	Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters.
Finland	Gold...	Mark	.193	Gold: 20 marks ($3.859), 10 marks ($1.93).
France	Gold...	Franc	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs.
German Empire	Gold...	Mark	.238	Gold: 5, 10 and 20 marks.
Great Britain	Gold...	Pound sterling	4.8665	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	Gold...	Drachma	.193	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas.
Haiti	Gold...	Gourde	.965	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions.
India (British)	Gold...	Pound sterling*	4.8665	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy	Gold...	Lira	.193	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire.
Japan	Gold...	Yen	.498	Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.

NOTE.—The coins of silver-standard countries are valued by their pure silver contents, at the average market price of silver for the three months preceding January 1, 1913.

* The sovereign is the standard coin of India, but the rupee ($0.3244½) is the current coin, valued at 15 to the sovereign.

Country.	Standard.	Monetary Unit.	Value in Terms of U.S.Gold Dollar.	Coins.
Liberia	Gold...	Dollar	1.000	
Mexico	Gold...	Peso†	.498	Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions.
Netherlands	Gold...	Florin	.402	Gold: 10 florins. Silver: 2½, 1 florin, and divisions.
Newfoundland	Gold...	Dollar	1.014	Gold: 2 dollars ($2.027).
Norway	Gold...	Crown	.268	Gold: 10 and 20 crowns.
Panama	Gold...	Balboa	1.000	Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions.
Paraguay	Silver.	Peso	.422	
Persia	Silver.	Kran‡‡	.0875	Gold: ½, 1, and 2 tomans ($3.409). Silver: ¼, ½, 1, 2 and 5 krans.
Peru	Gold...	Libra	4.8665	Gold: ½ and 1 libra. Silver: sol and divisions.
Philippine Islands.	Gold...	Peso	.500	Silver peso: 10, 20 and 50 centavos.
Portugal	Gold...	Milreis	1.080	Gold: 1, 2, 5 and 10 milreis.
Roumania	Gold...	Leu	.193	
Russia	Gold...	Ruble	.515	Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks.
Santo Domingo	Gold...	Dollar	1.000	
Servia	Gold...	Dinar	.193	
Siam	Gold...	Tical	.3708	
Spain	Gold...	Peseta	.193	Gold: 25 pesetas. Silver: 5 pesetas.
Straits Settlement.	Gold...	Pound sterling§	4.8665	Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden	Gold...	Crown	.268	Gold: 10 and 20 crowns.
Switzerland	Gold...	Franc	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs.
Turkey	Gold...	Piaster	.044	Gold: 25, 50, 100, 250 and 500 piasters.
Uruguay	Gold...	Peso	1.034	Gold: peso. Silver: peso and divisions.
Venezuela	Gold...	Bolivar	.193	Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars.

† Seventy-five centigrams fine gold.
‡ Value in Mexico, $0.498.
§ The current coin of the Straits Settlements is the silver dollar issued on Government account, and which has been given tentative value of $0.5677.
‡‡ The Gold Kran $0.1704.

Russian Weights and Measures.

1 Dolia	= .6857 grs. troy	= (for gold at £3 13s per oz.) 1 1/4d.
1 Zolotnik	= 65.8329 grs. troy	= (for gold at £3 13s per oz.) 10s.
1 Funt	= 13.1665 oz. troy	= (for gold at £3 13s per oz.) £48.
1 Pood	= 526.6632 oz. troy	= (for gold at £3 13s per oz.) £1922.
1 Pood	= 36.11 lb. av.	
62.025 Pood	= 1 ton (2240 lb.).	
1 Arschin	= 2 ft. 4 in.	
1 Sashen	= 7 ft.	
1 Deciatine	= 2400 sq. sashens	= 2.7 acres.
1 Verst	= 500 sashens	= 1166 yd. or 2/3 mile approximately.

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INTRODUCTION

Since taking up the work of preparing the present volume of MINERAL INDUSTRY, the Editor has met with a number of questions that seem to indicate that a very appreciable percentage of the mining and metallurgical public does not have a proper understanding of the reasons for an undertaking of this kind. The object in compiling this volume has been to make as complete a record as possible of the progress of the year in the mining and metallurgical industries. Production statistics are of course an important part of a record of this kind, and have been used extensively. So far though as the production statistics are concerned, the figures given are taken largely from the official reports of the countries concerned, and so if production statistics alone are sought, more detail will be given in the various reports than can be duplicated here. But the aim in compiling MINERAL INDUSTRY is to make the volume not merely a record of *productions*, but also of *progress*. With this in view, the attempt has been made to combine the more important statistics, from whatever source they may be gleaned, with such extracts from the current literature as have an important bearing on the subject in question, and sufficient discussion of the prevailing commercial conditions to show the trend of the financial side of the industry; in short, to prepare, so far as possible, a well-rounded review of the progress of the year in each of the various mineral and metallurgical industries that will, on the one hand, serve the needs of the average reader, the technical man, the business man or the student; and on the other hand, while not being complete enough fully to meet the demands of the specialist or investigator, will furnish him with the key to the situation, and the foundation on which to build a more detailed investigation of the subject.

A mere scissors-and-paste compilation of the available data, while of some value, is open to much improvement; the material should be put together by one who is thoroughly familiar with the general conditions surrounding the industry as a whole, and one who is able to weigh the relative importance of such information as is to be included in the report. With this in view, this volume, more than any of its predecessors, has been put into the hands of outside contributors. Wherever possible the preparation of the article was turned over to a specialist in that particular

line, so that the reader would get the benefit not only of the particular information included in the report, but also that specialist's weighing of the relative importance of that information.

A number of the mineral industries, particularly those connected with the pottery and building trades, are so widely scattered that their treatment is beyond the scope of a general report of this kind. A few industries relating to manufactured substances are included, where the production of the manufactured material is closely associated with that of the raw material, or where it is replacing to a considerable extent some natural material; *e.g.*, coke, artificial graphite and cement.

The statistics presented are the best available at the time of publication. Wherever possible they are the official figures of the country in question. Where it is known, the source of the statistics is shown.

For many of the production statistics we are indebted to the U. S. Geological Survey, and to the corresponding departments of the various foreign countries; for the United States imports and exports, to A. H. Baldwin, Chief of the Bureau of Foreign and Domestic Commerce. Acknowledgment is also due to many of the State Geological Surveys and mining bureaus for statistics and general information. In only one case was cooperation of this kind refused.

In most cases, the sources of information are shown in footnotes; any variation from this rule is an unintentional oversight. Our indebtedness to the columns of the technical press is gratefully acknowledged, particularly to *Engineering and Mining Journal, Mining and Scientific Press, Mining and Engineering World, Coal Age, Mining Journal, Canadian Mining Journal, Australian Mining Standard, L'Echo des Mines et de la Metallurgie* and *Glückauf*.

The make-up of the volume is very similar to the preceding volumes, the various industries being taken up in alphabetical order. The only change made is the placing together of a number of similar materials under a single class name, instead of listing them separately; *e.g.*, Alundum, Corundum, Garnet and Silicon Carbide, are all grouped together under the heading Abrasives. In the latter part of the volume will be found several articles of general interest. The statistical tables at the end are made up so far as possible from the official reports of the various countries. As these are often a year or more behind, the plan has been adopted of completing the tables to date, so far as possible, with unofficial statistics; this will undoubtedly increase the value of the tables, even though some of the figures used are only approximately correct. The unofficial figures in the tables are given in *italics* to distinguish them from the official figures. The index has been made as detailed as possible and all items are thoroughly cross-indexed. No matter how good it

be, a technical book can never reach its maximum usefulness unless it is properly indexed. And indeed, with a reference book, such as this is intended to be, one might almost paraphrase the old saw to read "A book is no better than its index."

A word concerning the use of MINERAL INDUSTRY will possibly not be out of place. As indicated on the title page, this volume is a supplement to Volumes I–XXI, but at the same time it is more than a supplement. It not only adds the data for the year 1913, but also gives corrections of the figures incorporated in previous volumes. Hence, it is important in using MINERAL INDUSTRY, always to use the latest volume even for figures for previous years, in order to get the benefit of these corrections, except, of course, in the case of the less important statistics, which are not carried from year to year, but are given only once.

In conclusion, the Editor expresses his gratitude and his indebtedness to the Contributors of the various articles incorporated in this Volume for their hearty coöperation, for to them is due a large measure of the credit for whatever of value the volume may contain.

G. A. ROUSH.

SOUTH BETHLEHEM, PA.
July 1, 1914.

ABRASIVES

Artificial Aluminous Abrasives

Alundum is oxide of aluminium (Al_2O_3), produced by complete fusion of bauxite in an electric arc furnace. The production of alundum is exclusive under patents held by Norton Co., whose electric furnace plant is located at Niagara Falls, N. Y.

The net effect of the dehydration, purification and crystallization from fusion of the oxide of aluminium from bauxite is a semi-crystalline material having the hardness and toughness of the purest corundum, but having the advantage of being uniform in all its properties. In fact, its degree of purity, character of impurities, physical properties, etc., are under control and can be varied within sufficiently wide limits to satisfy all abrasive requirements.

Incidentally, since alumina is one of the most refractory of the mineral oxides, taken alone or in fusion with other oxides and with silicates—especially those of ceramic use—alundum grain has a unique value as a refractory constituent in all laboratory wares. Being a good heat conductor, and having a high specific heat, it is an excellent material in muffles, especially those for electric furnaces. Since alundum is not easily attacked by acids or alkalis, and since in grain form it has comparatively large size, it has served well in filtering mediums of various shapes, such as cones and dishes used in the same manner as the Gooch crucible has been used.

The production of alundum during the past 9 years is as follows:

PRODUCTION IN THE UNITED STATES.

Year.	Pounds.	Value.
1904	4,020,000	$281,400
1905	3,612,000	252,840
1906	4,331,233	303,186
1907	6,751,444	405,086
1908	3,160,000	189,600
1909	13,578,000	814,680
1910	13,410,000	804,600
1911	11,116,000	666,960
1912	13,266,486	795,989
1913	20,203,600	1,212,216

Aloxite is a form of fused crystalline alumina or artificial corundum manufactured by the Carborundum Co. and produced in the electric furnace using emery ore as a source of alumina. The furnace operates at 375 kw. and consists of a carbon-lined base and removable fire-brick

side walls. Two vertical electrodes are employed. The furnace charge consists of crushed emery and coke, the function of the latter being to reduce the major portion of the iron and silica which are the principal impurities in emery.

The ingot of aloxite produced in each furnace weighs about 4 tons. It is broken down, sorted, crushed, washed, graded, concentrated and put through special processes to remove the impurities consisting principally of ferro-silicon and certain reduction products. The typical analysis is as follows:

Alumina	96.55
Silica	0.19
Iron oxide	0.21
Titanium oxide	2.09
Lime	0.96

In physical structure aloxite consists of pure alumina crystals with an interstitial or residual basis of the other components. The alumina crystals are identical in optical and crystallographic character with natural sapphire crystals of great purity. The fracture of both is choncoidal. Aloxite is pinkish brown in color and has a hardness slightly over 9. Aloxite has all the valuable abrasive and refractory properties of other well-known varieties of artificial corundum and is largely used in the manufacture of grinding wheels for steel, malleable iron and glass.

The production of aloxite by the Carborundum Co. at its Niagara Falls plant for the year 1913 was 2,413,190 lb. In October, 1912, the Carborundum Co. completed a plant at Sarrancolin, France, for the production of aloxite from bauxite. This plant was placed in operation with an initial capacity of 2000 h.p. with provision for enlargement to 5000 h.p., which is now in progress.

Corundum and Emery

By C. P. Berkey

Corundum is a simple mineral, Al_2O_3, in composition, next to the diamond in hardness, occurring in crystals and crystalline grains associated with certain igneous and metamorphic rocks. There is always some impurity, chiefly Fe_2O_3 and SiO_2. In the finest material analyses show 95 to nearly 99 per cent. Al_2O_3. The common rock varieties are useful for abrasive purposes and the rarer crystal varieties are used as gems. The mineral is in good demand, but the irregularity of its distribution and the difficulties and cost of its separation from the rock matrix hamper production.

Emery is a natural intergrowth or mixture of corundum and magnetite with associated substances such as spinel, quartz, etc. It is usually a

fine-grained close-textured rock of black color because of the presence of large amounts of magnetite. Its efficiency as an abrasive depends chiefly upon the corundum contained in it, but some varieties contain much spinel which is only one point lower in hardness than corundum itself, and therefore adds materially to the efficiency of the whole mixture.

Occurrence.—Corundum has been found in small amounts in Montana, Idaho, Colorado and California, but the principal belt of corundum-bearing rock within the borders of the United States lies on the easterly margin of the Appalachian province. Both corundum and emery are associated chiefly with certain basic igneous intrusives of the nature of peridotites, norites and pyroxenites that appear at several points along a belt reaching from Massachusetts to Alabama. The largest development of these rocks is in North Carolina, where the corresponding rock is a dunite, and the corundum occurs in irregular patches and tongue-like strips along and near the margins of the large intrusive mass. The corundum has been regarded as a sort of segregation effect in the crystallization of a magma over-rich in alumina. Some of the local variations, however, lead one to suspect a local segregation effect induced by the inclusion and absorption of masses of country rock by the magma. In North Carolina also there is corundum in the country rocks which are schists and gneisses. The origin of this variety is uncertain. Georgia and South Carolina have similar deposits and they have been reported from Virginia.

There are two occurrences of emery. One is in the Cortlandt series of basic intrusives near Peekskill, N. Y., and the other is in a narrow strip of amphibolite traceable for several miles at Chester, Mass.

Corundum occurs also in the province of Ontario, Canada, in Hastings and Renfrew counties, where it is associated with a series of nepheline-bearing syenites. It is a differentiation product of the intrusion, and occurs in pegmatitic stringers and irregular distributions in the igneous rock as one of the essential constituents.

The most interesting foreign occurrence is in the Urals where corundum is found at several places associated with or forming an essential constituent of a syenite. At Kyschtym this type of rock is so characteristically developed that it has been given a special name, Kyschtymite. It sometimes carries as much as 60 per cent. of corundum. Corundum also occurs in India in important amount and in the Transvaal and Madagascar.

The principal foreign occurrences of emery are the island of Naxos, Greece, Turkey and Bavaria.

Production.—Artificial abrasives have steadily encroached on the field formerly held by corundum and emery. The cost of mining and

separation of corundum is said to be about $40 per ton in the best American plants and there seems to be little chance of reducing it.

No corundum has been produced for the market in the United States since 1906. There have been several attempts to establish plants for its production, especially in North Carolina, but either the difficulty and expense of separation from the rock, or the irregularity and uncertainty of its distribution, or error in location and method have in all cases led to either temporary or permanent abandonment of the projects.

In Canada the working of corundum deposits has been more successful. A very large plant was running at Craigmont on the rich corundum syenite until last year when the mill was burned. This plant has not been rebuilt. The Manufacturers Corundum Co. now controls the whole of the Canadian corundum industry. The mines are in Carlow (formerly operated by the Ontario Corundum Co.) and in Raglan (formerly operated by the Canadian Corundum Co.).

Emery is produced from the Peekskill district in New York and the Chester district in Massachusetts. The working is all on a small scale from open cuts. The Peekskill emery is very impure and very variable. There are many small workings or places where there has formerly been some work done mostly by the owners of the farms as the demand is felt. The quality of the Chester emery is higher but operations there are virtually suspended.

All of the corundum and practically all of the emery used in the United States is imported, and nearly all comes from Naxos, Greece, where the production is under government control.

Canada.—The following tables summarize the production of corundum and emery so far as statistics are available and of apparent service for the present purpose. The tables covering Canadian production have been prepared by Mr. John McLeish of the Department of Mines, Ottawa.

CANADA CORUNDUM ORE MINED AND ANNUAL PRODUCTION OF GRADED CORUNDUM.

Year.	Corundum-bearing Rock Treated.	Grain Corundum Graded.	Percentage of Corundum in Rock as Determined by Recovery.
	Tons	Tons	Percent.
1900	.....	60	.....
1901	4,134	444	10.74
1902	7,996	806	10.08
1903	(a)8,877	839	9.45
1904	28,187	1,654	5.87
1905	23,571	1,681	7.13
1906	45,719	2,914	6.37
1907	60,532	2,682	4.43
1908	2,678	106	3.96
1909	35,894	1,579	4.40
1910	37,183	1,686	4.53
1911	41,795	1,641	3.93
1912	36,879	1,620	4.39
1913	12,290	763	6.21

(a) In addition to this amount which was milled in Canada, 267 tons were mined and shipped to the United States for treatment there.

ANNUAL SALES AND SHIPMENTS OF GRAIN CORUNDUM.

	Grain Corundum sold in Canada.	Grain Corundum sold for Export.	Total Sales.	Value.	Average Value per Lb.
	Tons	Tons	Tons	Dollars	Cents
1900	3	.....	3	300	5.00
1901	85	302	387	46,415	5.97
1902	106	662	768	84,465	5.49
1903	85	618	703	77,510	5.51
1904	116	877	993	109,545	5.51
1905	140	1,504	1,644	149,153	4.48
1906	162	2,112	2,274	204,973	4.50
1907	164	1,728	1,892	177,922	4.70
1908	99	990	1,089	100,398	4.60
1909	129	1,362	1,491	162,492	5.45
1910	106	1,764	1,870	198,680	5.31
1911	93	1,380	1,472	161,873	5.50
1912	64	1,896	1,960	239,091	6.10
1913	23	1,154	1,177	137,036	5.82

In 1912, 1459 tons of corundum valued at $152,249 and in 1913 920 tons valued at $100,156 was shipped by Canadian mines to the United States.

Germany.—The emery production in Bavaria for 1910, was 270 tons valued at $2892, and for 1911, was 210 tons, valued at $2256. Manufacturing of emery cloth is an industry of some importance in connection with this product.

Greece.—The production for 1912, was only 3359 tons. The average price was $19.04 per ton (metric) which is a little less than the price for 1911.

EXPORTS OF EMERY FROM NAXOS, GREECE.

Year.	Metric Tons.	Value.	Year.	Metric Tons.	Value.	Year.	Metric Tons.	Value.
1897	3,125	$65,683	1903	5,813	$120,348	1909	8,193	$164,762
1898	4,500	93,166	1904	6,353	131,531	1910	12,939	255,053
1899	5,139	106,181	1905	6,395	132,090	1911	9,845	202,119
1900	6,023	124,503	1906	8,030	166,251	1912	8,268	157,422
1901	6,080	125,582	1907	10,982	221,154	1913	1,440	.....
1902	4,315	88,841	1908	7,471	164,520			

India.—An increase of output of corundum has been noted in recent years from India, almost the whole production being from Madras. In 1910, the output was valued at $3074, in 1911, at $8123.

Madagascar.—It is reported in the *Daily Consular and Trade Report* that in 1912, 496 tons of corundum was exported from Madagascar and that a production of 1500 tons was estimated for 1913.

Turkey.—The official reports of the Department of Mines and Forests give the production of emery as 62,352 metric tons, valued at $302,407 for 1908, and 24,475 metric tons, valued at $118,703 for 1909.

Imports.—The imports of corundum and emery are classified into corundum ore, emery ore, corundum grains and emery grains; the last

two manufactured, ground, pulverized or refined. Emery grains are dutiable at 1 cent per pound—the others are free. For the fiscal year 1913, the corundum ore imported was 540 tons valued at $78,401 or $145.17 per ton. Corundum grains were imported to the amount of 1,855,400 lb. valued at $87,187 or 4.7 cents per pound. Emery ore to the amount of 18,911 tons valued at $328,211 or $17.36 per ton was imported, and emery grains to the amount of 886,315 lb., valued at $36,908 or 4.2 cents per pound. In addition there is considerable importation of manufactured wheels, etc., under a duty of 25 percent. But the exports exceed the imports of such goods.

STATISTICS OF CORUNDUM AND EMERY IN THE UNITED STATES.

Year.	Production. (a)		Imports.				
			Grains.		Ore and Rock.		Other Mfrs.
	Short Tons.	Value. (b)	Pounds.	Value.	Long Tons.	Value.	Value.
1899	3,970	$228,570	728,229	$29,124	7,435	$116,493	$11,514
1900	5,030	247,100	661,482	26,520	11,392	202,980	10,006
1901	4,305	146,040	1,086,729	43,217	12,441	240,856	10,926
1902	4,251	104,605	1,665,737	49,107	7,157	151,959	13,776
1903	2,542	64,102	3,595,239	109,272	10,884	194,468	17,829
1904	1,932	57,235	2,281,193	109,772	7,054	138,931	11,721
1905	(c) 2,315	19,677	3,209,914	143,729	11,072	185,689	17,996
1906	(c) 2,147	22,780	4,655,168	215,357	13,840	286,386	19,105
1907	(c) 1,089	12,294	4,282,228	186,156	11,235	211,184	15,282
1908	(c) 669	8,745	1,735,366	89,702	8,084	146,105	12,592
1909	(c) 1,580	18,185	2,696,960	132,264	9,836	186,930	19,803
1910	(c) 1,028	15,077	1,189,664	53,709	16,321	344,421	13,527
1911	(c) 659	6,778	1,382,813	76,027	10,822	245,459	15,158
1912	(c) 992	6,652	2,135,922	105,325	16,391	379,529	16,871
1913	(a) 959	4,785	2,741,715	124,095	19,451	406,612	15,006

(a) Statistics of the United States Geological Survey for 1901–1912. (b) Values have not much significance owing to the wide variation in the quality of the materials combined in the totals. (c) Emery only.

GARNET

BY D. H. NEWLAND

The production of garnet for abrasive uses represents a specialized and rather limited branch of the mining industry. Garnet has certain physical qualities which make it an ideal abrasive for some classes of work, notably in leather manufactures, and there is little likelihood that it will be displaced in the trade by other abrasive materials. But the market is not capable of absorbing more than a few thousand tons a year, at least on the present basis of prices. The production for many years has ranged between 4000 and 5000 short tons, the largest recent output having been in 1907 when it amounted to 6723 short tons, and

the average selling prices have remained steady at around $30 @ $32 a ton for the standard grades of crystallized garnet.

PRODUCTION OF ABRASIVE GARNET.[1]
(Short tons.)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1902	3,926	$132,820	1908	1,960	$64,620
1903	3,950	132,500	1909	2,972	102,315
1904	3,864	117,581	1910	3,814	113,564
1905	5,050	148,095	1911	4,076	121,748
1906	4,650	156,000	1912	4,947	163,237
1907	7,058	211,680	1913	5,308	183,422

[1] U. S. Geological Survey.

The important qualities of abrasive garnet seem to be those of hardness, toughness and cleavage. In hardness, the different garnet species vary considerably, and most of the garnet that is mined for abrasive uses is almandite (iron-alumina garnet) which has a hardness of 7–7.5 on the mineral scale, or between that of quartz and topaz. Well crystallized material which is relatively free of impurities has greater strength and stands up better under conditions of service than the finely granular mineral or that containing inclusions of other minerals. The common impurities of garnet are chlorite, mica, hornblende and pyroxene. It is an advantage, also, if the garnet possesses a parting or imperfect cleavage so that it breaks with one or more plane surfaces. Much of the Adirondack garnet shows a well-developed parting, and the faces often present a sharp chisel-edge that is not usual in any other natural abrasive. Color, of course, is not a criterion of value, but abrasive manufacturers express a preference for the darker shades which in the crushed product appear almost a ruby red. The garnet crystals should also be sufficiently large so that when they are freed from their matrix by crushing or other means, they will afford a desirable assortment of sizes. The normal result of milling operations is to produce an excess of the finer sizes.

Notwithstanding the wide distribution of garnet as a component of the metamorphic rocks, especially the gneisses and schists, there appear to be few localities where the material has the essential qualities and occurs in sufficient quantity to be commercially valuable. In this country the most productive deposits are found in the Adirondacks. North Carolina and New Hampshire have supplied small quantities in recent years, and there are mines, now inactive, in Maine, Massachusetts, Connecticut and Pennsylvania. The distribution and local features of the deposits have been described in preceding volumes of the MINERAL INDUSTRY, notably in Vol. VI and Vol. XXI.

For the last 4 or 5 years the domestic supply of the mineral has been supplemented by imports amounting to a few hundred tons annually

of Spanish garnet. This garnet is said to be of placer origin and is obtained by washing the sands of certain streams in the province of Almeria. According to the American consul at Madrid (*Daily Consular and Trade Reports*, March 13, 1914) there were three producers of such garnet in 1911, and their output amounted to 600 tons. As nearly all of the output comes to the United States it is evident that the utility of abrasive garnet is not generally recognized in the European countries, and so far as known, no other garnet mining industry has been established on that continent. The Spanish garnet is too fine in size to be a vigorous rival of the American product. The present value of the product is stated to be $7.75 a ton at the mines and the expense of shipment to the seaboard $6.65 a ton, so that it can be laid down in this country at under $20 a ton.

The output of garnet in 1913 was of the usual proportions. The Adirondack mines contributed the greater part as heretofore, their production having been 4665 short tons with a value of $145,445. There were three active mines, including those of the North River Garnet Co., H. H. Barton & Sons Co., and the Warren County Garnet Mills, all situated in the vicinity of North Creek, Warren County.

Reports from the collector of customs at Boston, New York and New Orleans show that a total of 547 short tons of abrasive garnet with a value of $8078, was imported in 1913. The imports for 1912 were 548 tons valued at $9271. The exports from Almeria are stated by the Consular agent to have been 1239 tons, which seems to indicate that the garnet in the last year may have found a market elsewhere than in the United States.

Silicon Carbide
(Carborundum.)

By F. J. Tone

The production of carborundum in the United States during 1913 was 12,597,590 lb. The progress of the industry may be seen from the following table of production from 1892 to 1913:

In the United States the Carborundum Co. of Niagara Falls is the only producer but since artificial abrasives have been placed on the free list the volume of importations has become considerable. The principal foreign producers are Norton Co. at Chippewa, Canada, whose product is marketed under the name of crystolon, Meyer & Schmidt of Rheinfelden, Germany, who produce silicon carbide under the name of carbosilite; Fabrique de Carborundum, Labathie, France; Elektrizitäts Werke Lonza, Geneva, Switzerland, and Arendals Smelteverk of Arendal, Norway. The latter plant has been placed in operation during the current year with an initial capacity of 1000 h.p. As an ore of silica the native

Norway quartz is used and English coke or coal is imported as a source of carbon. A feature of the furnace equipment of this plant is a movable transformer mounted on wheels, which is moved to each of the respective furnaces as they are successively placed in operation. A plant for the manufacture of silicon carbide and other artificial abrasives is now projected by the Exelon Co. at Thorold, Ontario.

PRODUCTION OF CARBORUNDUM IN THE UNITED STATES.

Year.	Pounds.	Metric Tons.	Value.
1892	2,145	1	.....
1893	15,200	7	.....
1894	52,190	24	.....
1895	225,930	102	.....
1896	1,190,600	540	$365,612
1897	1,242,929	564	153,812
1898	1,594,152	724	151,444
1899	1,741,245	791	156,712
1900	2,401,000	1,089	168,070
1901	3,838,175	1,742	268,672
1902	3,741,500	1,698	261,905
1903	4,760,000	2,160	333,200
1904	7,060,380	3,203	494,227
1905	5,596,280	2,539	391,740
1906	6,225,280	2,824	435,770
1907	7,532,670	3,418	451,960
1908	4,907,170	2,226	294,430
1909	6,478,290	2,938	388,697
1910	10,707,110	4,857	642,427
1911	10,376,620	4,707	622,597
1912	12,042,550	5,464	722,553
1913	12,597,590	5,717	$692,867.45

Abrasive Uses.—The principal use of carborundum is as an abrasive material and its field in grinding operations is now becoming clearly defined. Carborundum exceeds all other abrasives in hardness excepting the diamond but the hardness of a material does not determine its absolute value as an abrasive, for if such were the case, carborundum being the hardest of all would be the universal abrasive. On some materials garnet and quartz do better work than carborundum although vastly inferior in hardness. The limiting condition of a grinding operation is the production of heat. Excessive heat may either fill up the grinding wheel with fused metal and destroy its cutting surface or it may draw the temper of the steel or destroy the material being ground. This production of heat depends on four factors: first, the ultimate strength of the material being ground; second, the penetration of the abrasive; third, the rate of removal of stock; fourth, the contact area of the grinding tool to the work.

Carborundum is the most efficient abrasive on substances of low ultimate strength such as cast iron and brass, or on substances difficult to fuse such as pearl, carbon, marble or granite, which cannot fill up the wheel. The hardest abrasives such as carborundum can also be used

where the rate of removal of stock is low, where the contact surface is small, or where the character of the work causes a self-dressing action on the wheel. With substances of high ultimate strength such as steel, malleable iron and wrought iron it is imperative to use the softer abrasives such as aloxite and other aluminous abrasives. Penetration of the different abrasives depends largely on their hardness. Deeper penetration causes more work to be done resulting in higher production of heat.

Carborundum promises to revolutionize the work of cutting and molding granite in the same manner as has already been done in the marble industry. A 14-in. coping wheel will make cuts 1 1/2 in. deep and 3/16 in. wide in Bethel granite at the rate of 13 in. per minute. The results of molding cuts are equally efficient and machinery is now in process of development to displace all manual operations in granite working.

Refractory Uses.—The refractory uses of carborundum are of growing importance and two types of carborundum refractories are now employed; one consisting entirely of carborundum and the other containing a vitrified or ceramic binder.

Electrical Conductivity.—The electrical properties of silicon carbide are interesting not only because of its utilization in electric furnace construction but also because it has now a large field in the manufacture of resistance rods and lightning arresters.

Carborundum is a conductor of the second class. At ordinary temperatures its conductivity is very low, being several times less than carbon. With increase of temperature its conductivity increases very rapidly, it having a large negative temperature resistance coefficient. The conductivity of dense crystalline carborundum has been determined from 30° to 1400°. The samples tested were Refrax brick which is a form of densely compacted carborundum crystals without the addition of foreign binding material.

Temperature Degrees C.	Specific Resistance Ohms per cu. cm.	Temperature Degrees C.	Specific Resistance Ohms per cu. cm.
25	50	600	14.6
100	46.4	700	10.9
150	41.3	800	7.8
200	36.9	900	5.4
250	35.1	1000	3.7
300	32.7	1100,	2.1
350	28.1	1200	1.3
400	26.6	1300	0.96
450	23.0	1350	0.74
500	19.7	1400	0.65

The resistivity of Refrax brick varies with differences in porosity and chemical composition. However, it is interesting to note that at

temperatures above 1000° C. the resistivities have approximately the same value.

Preliminary determinations on the Carbofrax brick, which is a bonded brick consisting of carborundum and fire clay, denote a very much higher specific resistance than with the Refrax brick. However, the temperature coefficient is approximately of the same order of magnitude as is shown by the following determinations:

Temperature Degrees C.	Specific Resistance Ohms per cu. cm.	Temperature Degrees C.	Specific Resistance Ohms per cu. cm.
25	284,000	700	28,0000
200	270,000	800	24,000
410	250,000	1100	1,500
600	70,000	1200	04

Resistance to Chemical Agents.—Below 1000° C. no oxidation of carborundum occurs in pure oxygen. From 1000° to 1350° carborundum is slightly oxidizable in air. From 1350° to 1500° the silica formed is fused. From 1500° to 1600° oxidation is very much retarded by the fused silica coating. At 1750° oxidation becomes more rapid.

Neutral or reducing gases, such as carbon monoxide, nitrogen and hydrogen have little or no action on carborundum. Carbon dioxide and hydrogen dioxide only become active at their dissociation temperature or 1775° to 1800° C.

Fused sodium carbonate and fused alkali sulphates decompose carborundum. Sodium silicate attacks carborundum at 1300°. This is especially active in oxidizing gases and in the presence of oxidizing salts. Calcium oxide and magnesium oxide attack carborundum at 1000° C. Fused borax decomposes carborundum. Fused cryolite decomposes carborundum. Lead chromate oxidizes it. Fused caustic potash decomposes it. Sulphur vapors do not attack it at 1000° C. Fused potassium chlorate and nitrate are without action.

Silica attacks carborundum energetically in the electric furnace at 2000° to 2500° C. forming silicon. Carborundum forms silicides with the oxides of metals at the following temperatures:

Copper oxide	800°
Iron oxide	1300°
Nickel oxide	1300°
Manganese oxide	1360°
Chromium oxide	1370°

Boiling sulphuric and hydrofluoric acids are without action. Mixtures of nitric and hydrofluoric are without action. Henri Moissan found that at 600° C. carborundum is only superficially acted upon by chlorine, that at 1200° C. the action is complete. At 900° chlorine reacts with carborundum to form silicon tetrachloride leaving carbon.

At 1000° to 1100° chlorine reacts with carborundum to form silicon tetrachloride and carbon tetrachloride. Carborundum can be heated in platinum over a Bunsen but not over a blast without injury to the platinum.

Crystolon.—Carbide of silicon is also manufactured at Chippewa, Canada, under the trade name "Crystolon" by the Norton Co., of Worcester, Mass. The chief use of crystolon is in the manufacture of Norton Crystolon Grinding Wheels, Sharpening Stones, Rubbing Bricks, Razor Hones, Grinding Compound, and in grain form for polishing purposes. Incidentally, due to its high refractoriness, its comparatively low coefficient of expansion and high heat conductivity, crystolon is used as a refractory. Bonded with a ceramic bond, it is applicable to many refractory purposes. Norton Co. manufactures from crystolon a large variety of refractory products, which are rapidly finding favor in laboratories, both industrial and research.

Norton Co. has been manufacturing crystolon now for about 3 1/2 years, its present production being 3,000,000 lb. and having a value of $270,000.

ALUMINIUM

By J. W. Richards

The year 1913 was characterized by a steady growth of the aluminium industry. The production was the largest on record, the producing capacity was increased, many new uses for the metal were inaugurated, and altogether the industry flourished.

As in former years, the largest producers refuse to publish statistics of their output, so that only guesses can be made as to the production. We reiterate the expression of our regrets that those who are managing this great industry withhold these figures from the public. An outsider regards such secrecy as evidence either that the companies have mutual arrangements as to the amount each shall produce and are in practice deceiving each other, or else that the profits of the industry would figure out so enormous, if the true production were known, that competition would be more apt to arise. In either case they forfeit the confidence of the public, and have only themselves to blame if the public treats them with hostility on such questions as "Trusts," business agreements in restraint of trade, or the tariff.

The following figures are the estimated production of the principal countries for 1913:

	Metric Tons.	Pounds.
United States	29,500	64,900,000
Canada	5,916	13,015,000
France	15,000	33,000,000
Great Britian	10,000	22,000,000
Norway	2,500	5,500,000
Switzerland	10,000	22,000,000
Austria	5,000	11,000,000
Italy	800	1,760,000
	78,716	173,175,000

Grouped by producers, these figures would be:

	Metric Tons.	Pounds.
Aluminum Company of America Northern Aluminum Co. of Canada	35,416	77,915,000
L'Aluminium Francaise	15,000	33,000,000
British Aluminium Co	12,500	27,500,000
Aluminium Industrie Aktien Gesellschaft	15,000	33,000,000
Société d'Aluminio, Italy	800	1,760,000

These figures will be increased in 1915 by the following estimated capacities of new works:

	Metric Tons.	Pounds.
Aluminium Co. of America	6,500	14,300,000
Southern Aluminium Co	12,000	26,400,000
Swiss Company	2,500	5,500,000
	21,000	46,200,000
Estimated production in 1915	100,000	220,500,000

Imports of aluminium into the United States in 1913 were 10,539 metric tons, or 23,185,755 lb., making the apparent consumption of crude metal in the United States, in 1913, 40,000 metric tons, or 88,000,000 lb.

The U. S. Department of Commerce and the U. S. Geological Survey have been reporting in recent years the apparent *consumption* of crude aluminium in the United States, and not the *production;* and many journals and the press have miscalled these figures the *production.* It is important that the correct expression be adhered to, in quoting statistics from those sources.

When it is remembered that 30 years ago the world's yearly production was but 2 1/2 metric tons or 5500 lb. the amazing progress of this industry is realized. Aluminium has risen from a rare metal to a yearly tonnage exceeded only by iron, copper, lead, zinc and tin. It can confidently be expected that by the middle of this century it will rank next to or possibly even ahead of copper. It is already cheaper than tin, pound for pound, and cheaper than copper per unit of bulk or per unit of electrical conducting power, while the range of its applications and usefulness is extending more rapidly than that of lead or zinc. One of the great metallurgical achievements of the nineteenth century was undoubtedly the adding of aluminium to the metals of every-day life.

Imports and Estimated Consumption.

PRODUCTION, IMPORTS AND CONSUMPTION OF ALUMINIUM IN THE UNITED STATES

	Production.			Imports.			Exports.	Consumption.
				Crude.		Mfrs.		
	Pounds.	Value.	Per pound.	Pounds.	Value.	Value.	Value.	Value.
1899..	$6,500,000	$2,112,500	$0.33	53,622	$9,425	7,828	$291,515	1,838,238
1900..	7,150,000	2,288,000	0.32	256,559	44,455	5,989	281,821	2,056,623
1901..	7,150,000	2,238,000	0.31	564,803	104,168	5,580	183,579	2,164,169
1902..	7,300,000	2,284,590	0.31	745,217	215,032	3,819	116,052	2,387,389
1903..	7,500,000	2,325,000	0.31	498,655	139,298	4,273	157,187	2,311,384
1904..	7,700,000	2,233,000	0.29	515,416	128,350	478	166,876	2,494,952
1905..	11,350,000	3,632,000	0.32	530,429	106,108	33	290,777	3,015,364
1906..	14,350,000	5,166,000	0.36	770,713	154,292	1,866	364,251	4,957,907
1907..	26,000,000	10,920,000	0.42	872,474	181,351	1,124	304,938	(b)
1908..	13,000,000	4,095,000	0.315	465,317	80,268	2,334	330,092	(b)
1909..	15,000,000	3,345,000	0.223	5,109,843	745,963	12,878	567,375	(b)
1910..	12,000,000	2,736,000	0.228	12,271,277	1,844,830	.....	949,215	(b)
1911..	(c)28,600,000	5,720,000	0.20	(d)4,173,308	598,272	(d)63,899	1,158,603	(b)
1912..	(c)40,000,000	9,200,000	0.23	22,759,937	3,092,889	428,182	1,347,621	(b)
1913..	(c)64,900,000	13,600,000	0.21	23,185,755	3,905,977	1,090,229	966,094	.....

(a) Not reported. (b) Impossible to compute accurately in the absence of information as to unsold stocks. (d) from July 1 only. (c) estimated.

Market Prices

The market price of aluminium of first quality, over 99 per cent. pure, in cents per pound, varied in New York during 1913 as follows: January 26.5, March 26.9 to 27.1, April 26.75, May 25, June 23.5, July 23, August 21.5, September 21.5, October 19.75, November 18.5, December 18.8 to 19.

Prices in Europe were 6 cents per pound less than the above up to October 1, and 3 cents per pound less afterward. The International Aluminium Syndicate met in Paris in October, 1913, and fixed prices for all the producing countries except Italy, making the base price in Europe 2 francs per kilo, or 17.5 cents per pound. American prices average this price plus the duty of 3 cents per pound.

Progress in Various Countries

United States.—The Aluminum Co. of America has purchased 600 acres of ground at Marysville, Tenn., and will take 20,000 h.p. from the Tennessee Power Co. of Nashville. (*Daily Press.*) The complete electrical installation at Marysville will consist of alternating-current generators and rotary converters. The latter are 2500 kw., 500 volt, 60-cycle machines. The 60-cycle system has considerable advantage over the 25-cycle system, because of the higher available turbine speed which can be utilized at the generator, and installation costs throughout are less.[1]

The Southern Aluminium Co., a subsidiary of L'Aluminium Francaise, has a capital of $6,000,000, and is erecting its works at Whitney, N. C. The cost of the work undertaken by this company is stated as follows: Cash payment for water rights and ground, $1,500,000; dams, conduits, power-house, transmission lines, accessories, $1,500,000; railway track, employees' houses, offices, $1,000,000; general expenses during construction, $400,000; aluminium works, $1,100,000; working capital, $1,000,000. The Yadkin river will be dammed to give a fall of 52 meters (180 ft.), making a lake with a capacity of 200,000,000 tons of water. This will give 65,000 to 70,000 h.p. at Whitney and 20,000 h.p. at the lower falls. The total power, when utilized, will produce 12,000 to 15,000 metric tons of aluminium yearly. It is expected that the works will be in operation by the middle of 1915.[2]

Canada.—The Aluminum Co. of America is said to have contracted for 60,000 h.p. at Cedar Rapids, a power site on the north side of the St. Lawrence river 28 miles above Montreal. The con-

[1] F. D. Newbury, *Trans. Am. Electrochem. Soc.*, Vol. XXV.
[2] *Journal du Four Electrique*, May 15, 1913.

cessions held by the power company at this point will allow it to develop 160,000 h.p. (*Technical Press.*)

The Shawinegan plant of the Northern Aluminum Co. covers 10 acres, and includes a wire mill. There are 340 pots in operation, each producing 150 lb. of aluminium per day, 99.4 per cent. fine. The power plant is 40,000 h.p. = 30,000 kw.[1]

The average exports of aluminium from Canada for the years 1909–10–11–12 were 9,283,000 lb. yearly, valued at an average price of 13 cents per pound. The exports in 1913 were 13,015,000 lb., 5916 metric tons, valued at 13.5 cents per pound.[2]

Great Britain.—The profits of the British Aluminium Co. in 1912 were £194,823 (£41,922 more than in 1911). The output of aluminium was larger, but the profit per pound smaller.

The company has bought the works of the Anglo-Norwegian Aluminium Co. at Vigeland, Norway. It has also bought an alumina works and rolling mill at Warrington.

France.—L'Aluminium Francaise has made a $4,000,000 bond issue, and has organized a central service for selling all the aluminium made in France. It has established a plant for casting and working aluminium at Chambery. It has rented the power of the Société de l'Aluminium du Sud-Ouest at Arreau in the Pyrenees, and will establish there an aluminium works. It has also leased the water power of the Société des Forces motrices de l'Eau d'Olle.[3]

The Société des Produits chemiques d'Alais et de la Camargue, at its annual meeting October 1, 1913, voted an increase of 17,500,000 francs in its capital stock, of which 3,500,000 francs is for the absorption of the Société des Produits electrochimiques et metallurgiques des Pyrenees, at Aznat, near Tarrascon-sur-Ariege. This absorption will increase this company's producing capacity 25 per cent.[4]

Mr. H. Gall[5] estimates the capacity of the French plants at the end of 1913 as 19,000 metric tons (41,800,000 lb.), utilizing 65,000 kw. (87,000 h.p.).

Switzerland.—The profits of the Aluminium Industrie Aktien Gesellschaft of Neuhausen in 1913 were 5,600,000 francs ($1,288,000). A dividend of 20 per cent. was declared. It is proposed to increase the capital of 25,000,000 francs to 33,775,000 francs. The Oerliken Co. of Zurich has equipped the Chippis plant with 3 generators of 4000 h.p. each. At 300 r.p.m. they will each give 8000 amperes at 375 volts.[6]

[1] Economic Minerals and Mining Industries of Canada, Ottawa, 1913.
[2] Mineral Production of Canada, 1913.
[3] *Journal du Four Electrique*, June 1, 1913.
[4] *Journal du Four Electrique*, October 13, 1913.
[5] *Journal du Four Electrique*, February 1, 1914.
[6] *Journal du Four Electrique*, Mar. 13, 1914.

Norway.—The British Aluminium Co. has acquired the plant of the Anglo-Norwegian Aluminium Co. at Vigelandsfos, Veninsla, near Christiansand, and has increased its annual capacity to 2000 metric tons. This company manufactures its own electrodes.

L'Aluminium Francaise has acquired water power at Tyssaa, on the Hardanger Fjord, near Odda, to manufacture aluminium power transmission cables.[1]

Germany.—This country manufactures no aluminium. Importations of aluminium and its alloys into Germany in 1913 are given as 15,500 metric tons.

Belgium.—The Peniakoff process received its *coup de grace* when the Société de l'Aluminium et ses Dérivés (Procédé Peniakoff) was dissolved by the stockholders on January 17, 1913. Mr. Gaston Deversins of Brussels was made receiver.

India.—Mr. Alfred Chatterton reports in the *Madras Mail* that the importations of aluminium into India for the year ending March 31, 1913, were 4,010,608 lb., valued at $850,485. The economic question is not important for India, since it merely takes the place of brass and copper, but the hygienic advantage of aluminium over those metals is of the first importance. The industrial manufacture of aluminium ware in India has made great technical advances over the working of brass and copper. It would be of the first importance to India, however, to use water power in India to manufacture the aluminium needed, since the annual market might easily rise to 5000 tons or even 10,000 tons in a few years. The best power sites are in the Western Ghats, and the laterite deposits of India will furnish the raw material.[2]

Ores

Bauxite continues to be the ore of aluminium, and is mined on a very large scale. The U. S. Geological Survey gives the production in 1913 in the United States as follows:

	Metric Tons.	Value at the Mine.
Production	213,395	$997,698
Imports	21,778	85,746
Consumption	235,173	$1,083,444

This quantity was not all used in the aluminium industry, but part was used for producing alum and aluminium sulphate and in the manufacture of bauxite brick and "alundum" (fused alumina). Estimating these uses to consume 75,000 tons, there remains 160,000 tons absorbed by the aluminium industry of the United States and Canada. At a minimum content of 50 per cent. available alumina, this would furnish

[1] *Mining Journal*, Nov. 1, 1913. [2] *Journal du Four Electrique*, Nov. 1, 1913.

80,000 tons of pure alumina, containing 40,000 tons of metallic aluminium (88,000,000 lb.). (For further information, see the chapter on BAUXITE.)

REDUCTION

Pascal and Jouniaux[1] contribute the best publication of the year bearing on the reduction of aluminium. Their work concerned itself with a study of the various fused baths from which aluminium could be extracted, and the fusibility of baths of different compositions.

To start with, they determined the melting points of the three primary substances used, as follows:

Cryolite (AlF_3. 3 NaF)	977° C.
Fluorspar (CaF_2)	1361° C.
Alumina (Al_2O_3)	2020° C.

Taking these substances two by two, they observed the following temperatures of beginning and ending of setting:

TABLE I.

Percentage.		Beginning of Setting.	End of Setting.
Cryolite.	Fluorite.		
100	0	977	977
90	10	961	947
80	20	932	907
70	30	948	903
60	40	1025	905
50	50	1095	902
40	60	1156	1052
30	70	1296	1152
0	100	1361	1361

TABLE II.

Percentage.		Beginning of Setting.	End of Setting.
Cryolite.	Alumina.		
100	0	977	977
95	5	969	958
90	10	955	910
80	20	924	901
75	25	946	906
70	30	1086	923
65	35	1210	1112
0	100	2020	2020

TABLE III.

Percentage.		Beginning of Setting.	End of Setting.
Fluorite.	Alumina.		
100	0	1361	1361
80	20	1300	1270
75	25	1280	1270
70	30	1349	1304
0	100	2020	2020

[1] *Zeitschrift für Elektrochemie*, 1913, p. 610.

Taking these substances three at a time, varying quantities of alumina were added to five mixtures of cryolite and fluorite in the proportions 9–1, 8–2, 7–3, 6–4, and 4–6 respectively. The results were as follows:

TABLE IV

Mixture of Alumina and:	Percentage Composition of the Mixture.			Beginning of Crystallization.	End of Setting.
	Cryolite.	Fluorite.	Alumina.		
Cryolite 90 per cent. Fluorite 10 per cent.	90	10	0	961° C.	947° C.
	81.82	9.09	9.09	951	917
	76.27	8.47	15.25	924	900
Cryolite 80 per cent. Fluorite 20 per cent.	80	20	0	932	907
	73.48	18.37	8.15	931	864
	66.66	16.67	16.67	906	862
	63.5	16	20.5	888 (min.)	868
	61.66	15.41	22.93	960	855
	59.57	4.88	25.55	1015	874
Cryolite 70 per cent. Fluorite 30 per cent.	70	30	0	948	903
	64.95	27.83	7.22	929	892
	59.56	25.53	14.89	907	869
Cryolite 60 per cent. Fluorite 40 per cent.	60	40	0	1025	903
	56.25	37.5	6.25	1010	898
	53.17	34.81	13.02	993	868
	49.10	32.73	18.27	978	868
	46.8	31.2	22.0	968 (min.)	868
	45.5	30	24.5	1036	900 (?)
Cryolite 40 per cent. Fluorite 60 per cent.	40	60	0	1156	1052
	36.36	54.55	9.09	1170	930
	34.84	52.26	12.90	1170	868
	30	45	25	1154 (min.)	920
	28.8	43.2	28	1290	938
	12.75	72.25	15	1267	1247
	58.2	23.2	18.6	904	868

In the system cryolite-fluorite, the cooling curves show two definite arrests, the eutectic corresponding to 74.6 per cent. cryolite and 25.4 per cent. fluorite, setting at 905°, and consisting of two kinds of mixed crystals corresponding to 20.5 and 50 per cent. of fluorite.

The system cryolite-alumina was investigated to 1400°. The eutectic corresponds to 24 per cent. Al_2O_3, melting at 904°, and consisting of mixed crystals corresponding to 20 and 29 per cent. of alumina.

The system fluorite-alumina shows a eutectic at 26.9 per cent. alumina, melting at 1270, and consisting of mixed crystals corresponding to 20 percent and 28.5 per cent. alumina.

The ternary eutectic consists of

Cryolite	59.3 per cent.
Fluorite	23.0 per cent.
Alumina	17.7 per cent.

The eutectic temperature is 868°.

The solidus consists of 6 surfaces, running together to a triangular field, whose angles are situated at the following points.

TABLE V.

	Cryolite.	Fluorite.	Alumina.
I	77	16	7
II	60	15	25
III	34	54	12

In the baths used in the aluminium industry, the proportion of fluorite must be less than 36 per cent. to keep the melting point of mixture under 950°, where the cryolite and alumina are used in proportions of 3 or 4 to 1. These correspond to only a small part of the whole field.

Lorenz, Jabs and Eitel[1] give some further observations on nearly the same subject. They found the cryolite-alumina eutectic at 11 per cent. of alumina, melting at 937° C. Adding sodium fluoride to cryolite, they found the eutectic mixture to lie near $AlNa_3F_6.3NaF$, or 60 per cent. cryolite and 40 per cent. sodium fluoride, melting at 886°.

It is to be regretted that none of the above investigators tested mixtures of cryolite with aluminium fluoride, such as is recommended in the Hall patents.

Properties, Working, Plating, Etc.

Specific Gravity.—F. J. Brislee[2] found:

Composition.			Density at 4° C.
Al	Fe	Si	
99.11	0.56	0.33	2.706
99.64	0.15	0.21	2.703

A cast slab of the first metal was rolled fram 2 in. down to 0.018 in., without annealing; wire was drawn from 0.3-in. rod to 0.072 in.

Density of metal as cast	2.706
Rolled, hard	2.709
Rolled, annealed 14 hours a 450° C	2.710
Drawn, hard	2.703
Drawn, annealed	2.706

In all cases the density increased 0.003 on annealing.

The polished surface of the metal was etched with dilute hydrofluoric acid (1 to 8), with subsequent immersion in 60 per cent. nitric acid for a few seconds. Under the microscope, cold-worked aluminium thus etched shows no crystalline structure, but shows flow lines indicating the direction of working. Cold-worked metal is probably less crystalline, or more amorphous, than the annealed metal.

Modulus of Elasticity.—F. J. Brislee (*loc. cit.*) gives mechanical tests on aluminium containing 99.37 Al, 0.28 Fe and 0.35 Si. The results were 6892 to 6918 kg. per square millimeter, or 984,600 to 988,300 lb. per square inch.

[1] *Zeit. f. anorg. Chem.*, 1912, p 39.

[2] *Transactions Faraday Society*, **9**, 162.

Electric Conductivity.—H. Gewecke[1] states that this property is increased in sheet aluminium 10 per cent. by annealing 2 hours at 215° C., or 1 hour at 230°, the mechanical properties remaining meanwhile almost constant. Wire behaved similarly as regards conductivity, but its mechanical strength was decreased. There was no change produced in the microstructure by the heating. The metal contained 98.82 Al, 0.61 Fe and 0.41 Si.

Prof. E. Wilson[2] exposed wires of best copper, commercial aluminium and of "duralumin" to the London atmosphere for 2 years. The pieces were each 0.126 in. in diameter by 70 ft. long. They all increased in electric resistance by the following amounts: copper 2.0 per cent., aluminium 4.4 per cent., duralumin" 8.2 percent.

Refining.—Dr. W. Borchers and Otto Barth[3] refine or deoxidize aluminium by alloying it with the cerium metals in quantities up to 0.2 percent. They get the cerium into the metal by adding anhydrous fluorides of the cerium metals to the electrolytic bath during the manufacture of the metal.

Casting.—Patterns must allow shrinkage of 1 in 59. Green sand is used, loosely stamped on, so as to oppose no resistance to shrinkage. The inner surface of the mold may be sprinkled with graphite. When melting in crucibles, the latter may be of graphite or iron, but the melting point of the metal must not be much exceeded. The casting is done quickly in sand, but slowly in metal molds, and the pieces are taken out of the sand as quickly as possible. Large pieces can be surfaced by the sand blast, while smaller castings are dipped in soda solutions and brushed off. The iron crucibles used are made by the use of large amounts of steel turnings, and will last 150 to 200 meltings. Casting aluminium with 8 per cent. of copper, a temperature of 662° is used, and in iron crucibles zinc chloride is practicable as a purifying flux.[4]

Melting Scrap Sheet.—When melting scrap sheet aluminium, the oxide carries into the castings, causing the metal to crack when worked. Chloride of zinc acts well as a flux, the small amount of zinc reduced into the metal not injuring its properties. It may also absorb nitrogen from the air, if not well covered, and thus also become brittle.[5]

Granulating.—Bamberger and von Jüptner[6] described an explosion which occurred when melted aluminium was being poured through a sieve into water, to granulate it. A slight first explosion was followed by a second more violent one which killed two men. It is supposed that

[1] *Electrician*, Vol. LXXII, p. 450, through *Chemical Abstracts*, 1914, p. 1049.
[2] *Brit. Assn. Adv. Sci.*, Birmingham Meeting, 1913.
[3] German Patent, 246. 484 of 1913.
[4] *Stahl und Eisen*, September, 1913, p. 1613.
[5] *Brass World*, Dec., 1913.
[6] *Zeit. angew. Chem.*, **26**, 353, 1913.

after the first explosion the men dropped the whole mass of liquid metal into the water.

Coloring.—Albert Lang of Karlsruhe treats aluminium with hydrochloric acid, copper chloride, or iron chloride, and then heats it without rinsing. This leaves a film on the surface, which may be lacquered or enameled. The coatings are white, black or gray, respectively.[1]

Plating with Aluminium.—S. Uyeno[2] of Tokyo has patented in England the immersing of galvanized or tinned articles into melted aluminium at not over 700° C., rubbing the immersed surface with steel brushes.

Nickel Plating on Aluminium.—Messrs. Canac and Tassily,[3] in a paper to the French Academy of Sciences, describe a method said to give a perfectly adhering nickel deposit, such that plates will stand hammering without cracking the deposit. The aluminium is plunged in a boiling bath of caustic potash, brushed with milk of lime, dipped several minutes into a 2 per cent. solution of potassium cyanide, and washed in water between each treatment. It is then dipped into a bath containing 500 grm. HCl, 500 c.c. H_2O and 1 grm. $FeCl_2$, until it takes on a dull metallic appearance. It is then washed again in water and put into the nickel depositing bath, nickel chloride solution being found to give a better plating than nickel sulphate. The microscopic film of iron is supposed to bind the nickel to the aluminium. The aluminium may be rolled, bent or worked, without separating the plating. Prof. H. Le Chatelier vouched for the accuracy of the statements.

Compound Metal Sheet.—L. W. Tebbetts,[4] of the Hoyt Metal Co., St. Louis, Mo., patents the compound metal sheet obtained by placing a slab of aluminium in a mold and casting soft metal, such as antimonial lead, around it, until the aluminium is entirely surrounded. The compound slab is then rolled. The two metals adhere closely without being fused or alloyed together at their contact surface. Antimonial lead, britannia metal, solder, tin, or any ductile metal may be used.

Soldering.—Charles Willmott,[5] of Smethwick, England, patents a solder containing tin 86 per cent., bismuth 14 per cent. It is used with a blow-pipe, simply scraping the surface but using no flux.

Alloys

Casting Temperature.—H. W. Gillett, in *Metal Industry*, 1913, page 193, shows that hot-cast bars are usually about 20 per cent. weaker than those cast at proper temperatures. Making tests on sand-cast bars,

[1] *Brass World*, December, 1913.
[2] *Brass World*, December, 1913.
[3] *Journal du Four Electrique*, Feb. 1, 1914.
[4] *Brass World*, December, 1913.
[5] *Brass World*, December, 1913.

broken in wedge grips, the section being 0.5 in. in diameter by 2 in. long, the following results were obtained:

No.	Composition.	Pouring Temperature.		Tensile Strength, Lb. per Sq. In.	Pouring Temperature.		Tensile Strength, Lb. per Sq. In.
		C°.	F°.		C°.	F°.	
1	Commercial Aluminium	759	1,400	10,500	871	1,600	8,000
3	Aluminium plus 8 per cent. copper	663	1,225	20,000	871	1,600	15,500
11	Aluminium plus 16 per cent. zinc	663	1,225	24,000	843	1,550	17,000
15	Aluminium plus 32 per cent. zinc	663	1,225	35,000	843	1,550	30,000
30	Aluminium plus 3 per cent. copper, 15 per cent. zinc, ½ per cent. manganese	663	1,225	30,000	843	1,550	20,000
31	Aluminium plus 2½ per cent. copper, 19 per cent. zinc	663	1,225	33,000	843	1,550	25,000
35	Aluminium plus 1¼ per cent. copper, 30 per cent. zinc	663	1,225	42,000	843	1,550	34,000
37	Aluminium plus 2 per cent. manganese	649	1,200	19,000	843	1,550	18,500
43	Aluminium plus 5 per cent. copper, 3 per cent. tin	658	1,215	16,800	815	1,500	15,000
44	Aluminium plus 6 per cent. copper, 1 per cent. nickel	705	1,300	18,200	871	1,600	14,500
52	Aluminium plus 5 per cent. magnesium	677	1,250	20,500	759	1,400	20,000

Cobalt Alloys.—The addition of 0.5 percent of cobalt to aluminium reduces its melting point, but further additions have higher melting points. The compound $CoAl_4$, with 33.4 per cent. of cobalt, has been shown to exist, with a melting point of 1100° C. Between it and pure aluminium are a series of useful alloys. With 9 to 12 per cent. cobalt there is obtained a dense alloy of rather coarse crystalline structure, harder and more workable than pure aluminium and much more resistant to corrosion. The coarsely crystalline structure prevents high mechanical strength, but the addition of tungsten and molybdenum diminish the size of the crystals and increase the strength; 0.8 to 1.2 per cent. of tungsten, or 0.6 to 1 per cent. of molybdenum with 8 to 10 per cent. of cobalt make a fine-grained strong alloy.

Phosphorus.—Phosphor copper or phosphor zinc is recommended[1] as a cleaning and purifying flux to use when melting aluminium alloys; 50 to 100 grm. of the 25 per cent. phosphorous alloy are used to a crucible full of alloy, being wrapped in soft paper and held in tongs or a stirring stick at the bottom of the crucible until dissolved.

Magnesium.—Three to ten per cent. of magnesium is said to give a useful bearing metal alloy with aluminium.

Boron.—E. D. Gleason[2] proposes to fuse aluminium under a layer of 3 parts fluorspar and 1 part boracic acid, at a high temperature. This produces an aluminium-boron alloy, which is then melted with copper and some black manganese oxide to form a boron-aluminium bronze. This bronze is said to be superior in physical properties to ordinary aluminium bronze, and not to tarnish so rapidly.

[1] *Stahl und Eisen*, Nov. 27, 1913, p. 1984.

[2] *Brass World*, December, 1913.

Zinc.—Macadamite is a patented alloy said to contain 6 to 27 per cent. of zinc, with small quantities of silver. It is melted with sal ammoniac or zinc chloride as flux, 1 part to 1000 of alloy, and when cast at 1300°–1400° F. has the following physical properties:

Tensile strength, per square inch	44,250 lb.
Elastic limit, per square inch	35,400 lb.
Compressive strength, per square inch	126,000 lb.
Transverse strength, per square inch	87,200 lb.
Torsional strength	60,000 lb.
Specific gravity	3.2

Duralumin.—The properties of the metal now being put on the market are given as:

Cast: tensile strength	36 to 42 kg./sq.mm.
	51,000 to 60,000 lb./sq. in.
Elastic limit	20 to 28 kg./sq. mm.
	28,500 to 40,000 lb./sq. in.
Elongation	16 to 22 percent.
Hardness	110 (Brinell test)
Specific gravity	2.8
Melting point	650° C.
Hard worked:	
Tensile strength	45 to 58 kg./sq. mm.
	64,000 to 83,000 lb./sq. in.
Elastic limit	40 to 50 kg./sq. mm.
	57,000 to 71,000 lb./sq. in.
Elongation	3 to 11 per cent.
Hardness	150 (Brinell test)

Copper.—A. A. Read contributed a paper to the meeting of the Institute of Metals at Ghent, August 29, 1913, from which we abstract the following: The aluminium used contained 0.17 silicon, 1.18 iron, 0.05 sodium. Phosphor copper, 15 per cent. alloy, was used. The copper was melted under charcoal in a crucible, well poled, and the aluminium, heated almost to melting, forced down into the copper. A marked rise of temperature was observed while alloying. The alloy was stirred with a graphiterod, and the phosphor copper flux added, wrapped in thin sheet copper as a cartridge. The mix was stirred skimmed, and poured into ingots 2 1/4 in. in diameter by 18 in. long. Maximum loss of aluminium 0.2 per cent. The oxidation of that quantity should raise the bath temperature 150° C. Phosphorus in the alloy 0 to 0.2 per cent.; aluminium 4.88 to 5.02 in one set, and 9.96 to 10.07 in another. If over 0.2 percent of phosphorus is added to the 10 percent bronze, the metal gives an odor of PH_3 when being filed or turned, due to aluminium phosphide.

The electrical resistivity of the two alloys, 5 and 10 percent aluminium, is almost alike, being 10 microhms for bronze free from phosphorus and 11 microhms for either bronze with 0.1 per cent. phosphorus. The melting points were as follows:

	10 Per cent. bronze.	5 Per cent. bronze.
No phosphorus content	1038° C.	1054° C.
0.2 percent phosphorus	1023° C.	1047° C.

A stream of ordinary soft water had no corrosive effect on these bronzes in 112 days. Sea water, changed every 14 days, darkened the

plates in 83 days, but left them smooth. Small quantities of phosphorus reduced the loss of weight, evidently by eliminating impurities and giving greater homogeneity.

The paper closes with some excellent microphotographs, showing the effects of annealing the bronzes.

Uses

Electrical.—The French manufacturers of aluminium made brilliant exhibits of aluminium at the 1913 Ghent Exposition. Among them were arched collecting rods for electric street cars; cold-drawn tubes for electrical conduits in buildings, as used in the new department store of La Belle Jardinière, in Paris; fuses for safety blow-outs.

The Pacific Light and Power Co.[1] of Los Angeles installed, in 1913, a 270 mile (450 km.) transmission line consisting of 6 conductors each of 500 sq. mm. section, transmitting 26,000 kw. at 150,000 volts. The towers are 230 meters (750 ft.) apart.

The transmission line from Big Creek to Los Angeles was opened Nov. 8, 1913. It transmits 10,000 kw. at 135,000 volts. The conductor is aluminium with steel core, weighing 1.135 tons per kilometer (2 tons per mile). The whole line requires 2700 tons of cable.[2]

The electric tramways of Paris are putting in aluminium cables up to 1000 sq. mm. section, carrying current at 500 volts. They will use 300 tons of aluminium, at a saving of 8 to 10 per cent. over copper cables.

The journal *Engineering*, 1913, page 812, estimates that 15 percent of the output of aluminium or about 9000 tons yearly, is used for transmission cables. It should be over 99.25 per cent. pure. It resists the sea air and sulphur dioxide (such as near coke ovens) better than uncovered copper wire. The larger size gives more radiating surface than the copper wire of the same conductivity (50 percent greater), and consequently the cables work cooler under high loading. Tensile strength, in tons per square inch: $T = 16.5 - 2.4\,d$, where d is the diameter in inches. Elongation 2.5 to 3 per cent. Elastic limit 70 per cent. of the breaking strength. On the continent of Europe there are 800 miles of aluminium cable in use, at voltages up to 60,000.

Transportation.—The use of aluminium and its alloys for automobile parts is increasing enormously. The electric tramways of Paris are using it for car bodies, as well as for package racks, clothes hooks, etc. It is used very largely in aeroplanes.

Chemical Uses.—Professor Trillat at the Pasteur Institute, Paris, has made a special study of its use in breweries, distilleries, and in the fermentation industries.

[1] *L'Elettrotecnica*, March 15, 1914.

[2] *Journal du Four Electrique*, March 13, 1914.

ANTIMONY

While no antimony was produced in the United States last year from domestic ore, a considerable quantity was saved in the form of antimonial lead, which is obtained at the smelters of precious metals in the course of their operations, and large quantities of antimonial alloys are recovered from secondary sources, such as scrap bearing and type metals, solder, and antimonial lead drosses. From antimonial lead of both domestic and foreign origin, but smelted in the United States, according to figures compiled by the United States Geological Survey, 1,949 short tons of antimony were produced, while from old alloys, scrap, dross, etc., 2506 short tons of antimony were recovered.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK. (a)
(Cents per pound.)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1904.													
Cookson's	6.938	7.594	7.875	7.875	7.531	7.200	7.188	7.188	6.913	6.984	7.592	8.388	7.439
Hallett's	6.250	6.781	6.825	6.750	6.578	6.438	6.485	6.688	6.537	6.578	7.328	8.150	6.783
Others	5.688	6.203	6.475	6.406	6.203	5.961	5.969	6.062	6.015	6.172	7.204	8.068	6.371
1905.													
Cookson's	8.375	8.375	8.375	8.219	8.406	11.025	12.625	14.500	13.700	13.000	12.500	14.000	11.100
Others	8.063	8.063	7.638	8.125	8.406	10.175	11.875	13.500	12.900	12.000	11.250	12.750	10.400
1906.													
Cookson's	15.0	16.0	17.5	21.31	25.25	26.0	25.25	25.0	24.5	25.2	26.14	26.25	22.78
Hallett's	14.0	15.0	16.5	20.31	24.38	25.0	24.25	24.0	24.0	24.81	25.25	25.24	21.94
Others	13.5	14.25	16.15	20.25	23.31	24.0	23.19	22.75	22.25	23.63	24.50	24.70	21.73
1907.													
Cookson's	25.906	25.062	24.90	24.125	21.937	15.75	11.875	10.906	10.75	11.75	11.00	9.662	16.969
Hallett's	25.219	24.062	23.75	21.344	18.562	13.812	10.50	9.687	10.00	10.406	9.937	9.05	15.527
Others	24.156	23.437	23.025	20.875	17.75	12.65	10.125	9.375	9.65	10.047	8.906	8.068	14.840
1908.													
Cookson's	9.344	9.266	9.000	8.969	8.875	8.734	8.594	8.313	8.234	8.284	8.640	8.200	8.704
Hallett's	9.031	9.016	8.650	8.672	8.625	8.531	8.375	8.150	7.922	7.922	8.075	8.063	8.419
Others	8.344	8.406	7.988	8.297	8.250	8.094	8.125	7.850	7.609	7.625	7.775	7.688	8.004
1909.													
Cookson's	8.202	8.125	8.047	8.250	8.387	8.312	8.375	8.525	8.687	8.537	8.437	8.437	8.360
U. S.	8.075	8.000	7.843	8.031	8.150	8.062	7.875	8.125	8.125	8.012	7.937	7.937	8.015
Others	7.675	7.531	7.500	7.718	7.887	7.893	7.375	7.625	7.506	7.500	7.687	7.687	7.466
1910.													
Cookson's	8.500	8.469	8.359	8.438	8.438	8.241	8.175	8.278	8.313	8.263	7.922	7.625	8.252
U. S.	7.988	7.969	7.938	7.938	7.938	7.938	7.938	7.938	7.938	7.900	7.656	7.438	7.876
Others	7.738	7.578	7.313	7.438	7.438	7.438	7.400	7.328	7.313	7.400	7.188	7.063	7.386
1911.													
Cookson's	8.25	8.38	9.56	9.54	9.50	8.75	8.50	8.44	8.31	8.14	7.97	7.78	8.59
U. S.	7.74	8.02	9.13	9.13	8.97			7.94	7.84	7.71	7.61	7.50	8.16
Others	7.5	7.65	9.00	8.52	7.99	7.42	7.35	7.36	7.26	6.96	6.92	6.82	7.54
1912.													
Cookson's	7.53	7.27	7.65	8.05	8.02	8.09	8.42	8.59	9.12	10.30	10.39	10.21	8.90
U. S.	7.47	7.44	7.56	7.75	7.75	7.78	7.96	7.98	8.50	9.62	9.86	9.62	8.26
Ordinaries	6.88	6.83	6.86	6.94	7.10	7.21	7.50	7.70	8.26	9.30	9.30	9.18	7.76
1913.													
Cookson's	9.94	9.47	9.28	9.13	8.88	8.79	8.54	8.38	8.37	7.60	7.62	7.50	8.73
U. S.	9.53	9.09	8.85	8.50	8.37	8.27	8.08	7.91	7.93	7.27	7.30	7.25	8.22
Ordinaries	8.97	8.25	8.18	7.98	7.79	7.64	7.55	7.39	7.37	6.49	6.45	6.13	7.52

(a) From *Eng. Min. Jour.*

Except for the changes made by the new tariff, the antimony industry in 1913 was featureless. The market was quiet throughout the year, prices sagging generally from 10 1/4 cents per pound for Cookson's and and 9 1/8 cents for outside brands in January to 8 3/8 and 7 3/8 cents, respectively, in October, when tariff changes began to be reflected in the quotations. The import duty on antimony, which had formerly been 1 1/2 cents per pound, was changed to 10 per cent. *ad valorem*. This was followed by a corresponding drop. The prices at the end of the year were 7 1/2 cents for Cookson's, 7 1/4 cents for Hallett's and 6 1/4 cents for Hungarian, Chinese and outside brands.

The following table gives the antimony statistics for the United States:

ANTIMONY STATISTICS OF THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Imports.		Exports.		Production.			Consumption.
	Metals or Regulus.	In Ore.	Metal or Regulus.	Ore.	In Hard Lead.	From Domestic Ore.	From Imported Ore. (a)	
	Short tons	Short tons	Short tons	Short tons	Short tons	Short tons	Short tons	Short tons
1899....	1,580	1,991	*Nil.*	*Nil.*	1,586	234	796	4,196
1900....	1,816	3,018	21	*Nil.*	2,476	151	1,207	5,638
1901....	1,837	866	*Nil.*	25	2,235	50	336	4,458
1902....	2,871	840	37	104	2,904	*Nil.*	294	6,032
1903....	2,563	1,337	40	*Nil.*	2,552	*Nil.*	535	5,610
1904....	2,028	1,245	16	214	2,515	*Nil.*	412	4,939
1905....	2,869	988	*Nil.*	*Nil.*	2,561	*Nil.*	395	5,825
1906....	3,950	1,124	12	*Nil.*	2,358	150	450	6,866
1907....	4,331	1,380	24	6	2,240	105	552	7,204
1908....	4,057	1,640	1	5	2,621	180	656	7,513
1909....	4,826	1,693	3	*Nil.*	2,546	38	694	8,055
1910....	4,950	*Nil.*	*Nil.*	*Nil.*	2,277	30	*Nil.*	7,257
1911....	5,479	*Nil.*	*Nil.*	*Nil.*	1,783	*Nil.*	.....	.....
1912....	6,969	(b) 781	*Nil.*	*Nil.*	2,048	*Nil.*	.....	.....
1913....	7,667	25	(c) *Nil.*	*Nil.*	(d)4,455	*Nil.*	.....	.....

(a) Estimated at 40 per cent. extraction from net imports of ore. (b) Antimony contents of 964 long tons of ore, containing less than 10 per cent. lead. (c) 32 tons of antimony of foreign origin were exported in 1913. (d) 1949 tons from hard lead and 2506 tons recovered from old metal, scrap, dross, etc. Figures of U. S. Geological Survey.

The imports of antimony oxide for the fiscal year, ending June 30, are as follows:

IMPORTS OF ANTIMONY OXIDE.

	Pounds.	Value.
1908.....	709,662	$73,667
1909.....	595,095	65,596
1910.....	414,713	20,407
1911.....	942,616	50,371
1912.....	1,079,268	46,671
1913.....	1,819,323	97,447

PRODUCTION OF ANTIMONY METAL IN FOREIGN COUNTRIES.
(In metric tons.)

	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Austria	153	114	24	14	36	90	*Nil.*	207	162	*Nil.*	*Nil.*	*Nil.*	13
China(b)	.....	.....	.....	.....	.....	3,353	3,829	2,316	9,356	7,937	6,643	6,986	13,313
France	1,600	1,786	1,725	2,748	2,116	2,396	3,433	3,945	3,850	5,444	4,640	4,775	5,406
Hungary(a)	846	706	683	732	1,007	756	1,322	841	670	695	782	892	859
Italy	1,174	1,721	1,574	905	836	327	537	610	345	59	*Nil.*	*Nil.*	*Nil.*
Japan	349	429	528	434	321	190	627	248	198	157	120	97	80

(a) Regulus. (b) Exports of regulus and refined metal.

CHINESE ANTIMONY PRODUCTION.
(Long Tons.)

	Canton.	Wuchow.		Yochow.		Changsha.		
	Ore.	Ore.	Regulus.	Ore.	Crude.	Ore.	Crude.	Regulus.
1900	.....	237	.....	.....	.....	.....	.....	.....
1901	.....	71	.....	.....	.....	.....	.....	.....
1902	.....	.....	.....	200	1795	.....	.....	.....
1903	.....	.....	.....	2438	4554	.....	.....	.....
1904	473	.....	.....	1370	3265	224	851	.....
1905	261	.....	.....	340	1487	1774	1679	.....
1906	292	.....	.....	1199	733	2271	2375	.....
1907	504	.....	.....	2758	666	3092	1751	.....
1908	142	.....	3	1128	1903	853	5956	.....
1909	51	41	½	1964	974	1101	5542	240
1910	5	115	19	2190	930	1289	7147	803
1911	64	48	356	744	2874	501	7245	1566
1912	275	54	232	1214	373	680	5386	2012

China (By T. T. Read).—China is one of the chief producing countries and is likely to become even more important, with the decline of the French output. Antimony is produced in a number of places in the southern half of China, but the chief center is in Hunan. The ore occurs in a number of places west of the T'ung-ting lake, the principal town being I-yang. The ore is cobbed and handpicked before transporting it to Changsha, where several companies are engaged in its reduction to regulus. A good deal of ore is shipped, chiefly to Japan and France, though some comes to the United States. The exports of crude and refined regulus (not distinguished) were as follows: 6538 tons in 1910; 6876 tons in 1911, and 13,313 tons in 1912, according to the statistics of the Maritime Customs. Exports of ore were: 5670 tons in 1910, 6704 tons in 1911, and 2022 tons in 1912. Some of this ore came from Yunnan, and small amounts of regulus were produced in Kwangsi and Kwantung provinces. C. Y. Wang has recently published (*Engineering and Mining Journal*, Oct. 26, 1912, p. 777) an article of the antimony resources and production of China, which is the most comprehensive summary which has yet appeared. According to Mr. Wang, the principal mining centers are as follows: Hunan, I-yang, Anhwa, Sinhwa, Supu, Chenki, Pasa. Kwangsi, Fengyi, Lungan, Pin, Hochi, Tienho, Ining. Kwangtung, Kok-

kong Yingtak, Tsingyun, Fongshing, Tingan, Yuyuen, Yanfa. Yunnan, Paoning, Kaihwa. Kweichow, Siushan. More than a hundred antimony mining companies have been formed, and 8 smelting plants have been erected. Most of these companies have discontinued, for one reason or another. The Wah Chang Mining & Smelting Co. of Changsha and the Pao Tai Mining & Smelting Co. of Wuchow are the most important of those now in operation. The Pao Wah Mining & Smelting Co., capitalized at $120,000 has a concession granting a monopoly of the mining of antimony in Yunnan province, but has not started operations.

Bibliography

Brown, R. E.—The Replacement of Tin Oxide by Antimony Oxide in Enamels for Cast Iron. *Trans. Am. Ceram. Soc.*, 14, 740–55.

Campbell, S. G.—Oil Flotation in Treating Antimonial Ores. *Sch. Mines Quar.*, Nov., 1913.

Carpenter, H. C. H.—The Copper-Antimony Equilibrium. *Internat. Zeit. Metallog.*, 4, 300–22.

Eyer, P.—The Assumed Reduction of Antimonic to Antimonous Compounds. *Glashütte*, 43, 266, 327–8.

Chaney, N. K.—Electrolytic Deposition of Antimony. *Jour. Am. Chem. Soc.*, 35, 1482–90.

Hess, F. L.—Production of Antimony, Arsenic, Bismuth and Selenium in 1912. *Min. Res. of U. S.*, 1912.

Leroux, P.—Magnetic Study of the Constitution of some Antimony Alloys. *Compt. rend.*, 156, 1764–6.

McMurty, G. C.—Notes on the Smelting of Antimonial Concentrates. *Bull. 97, Inst. Min. Met.; Min. Eng. World*, 38, 9–11.

Mott, L. C.—Antimony: Its Ores, Metallurgy and Uses. *Min. Sci. Pr.*, Feb. 14, 1914.

Parravano, N.—The System Antimony-Selenium. *Gazz. Chim. ital.*, 43, I, 210–20.

Quercigh, E.—Oxysulfides of Antimony. *Atti accad. Lincei*, 21, I, 415-19.

Schleicher, A.—The Ternary System: Copper, Cadmium, Antimony. *Internat. Zeit. Metallog.*, 3, 102–6.

Schoeller, W. R.—Notes on Chinese Antimony Ores, Crude and Regulus. *Jour. Soc. Chem. Ind.*, Mar. 31, 1913.

Schoeller, W. R.—Ore Deposits of Hu-nan and Hu-peh, China. *Jour. Soc. Chem. Ind.*, May 31, 1913.

Vickers, C.—Antimony in Brass Mixtures. *Foundry*, 41, 322.

ARSENIC

The output of arsenic in the United States during 1913 was all in the form of white arsenic or arsenious oxide commonly known as "arsenic," and amounted to about 2375 short tons, valued at $142,340, against 3141 tons, valued at $190,757, in 1912, a decrease of 766 tons in quantity and $48,417 in value, according to the preliminary figures collected by the U. S. Geological Survey.

As in 1913, white arsenic was produced in this country only from smelter flue or bag-house dusts and by the same three firms which produced it in the preceding year. The Anaconda Copper Company saved white arsenic from fumes made in smelting Butte copper ores at the Great Washoe Smelter at Anaconda, Mont. At Midvale, Utah, the United States Smelting Company sublimed white arsenic from bag-house dusts collected in smelting tintic and other Utah copper ores. The American Smelting and Refining Company saved its output from flue dusts made from both domestic and foreign ores.

There is so little direct profit in the manufacture of white arsenic, owing largely to the long distances it must be shipped to market, that the smelting companies make it only because they must prevent its escape into the atmosphere. If the demand and prices justified a larger output the producton could be greatly increased.

STATISTICS OF WHITE ARSENIC IN THE UNITED STATES.

Year.	Production.			Imports.			Total.	
	Pounds.	Value.	Per lb.	Pounds.	Value.	Per lb.	Pounds.	Value.
1899	.....	.....	.....	9,040,871	$386,791	$0.04¼	9,040,871	$386,791
1900	.....	.....	.....	5,765,559	265,500	0.04⅝	5,765,559	265,500
1901	600,000	$18,000	$0.03	6,989,668	316,525	0.04½	7,589,668	334,520
1902	2,706,000	81,180	0.03	6,110,898	280,055	0.04⅝	8,816,898	361,235
1903	1,222,000	36,691	0.03	7,146,362	256,097	0.03⅝	8,368,362	292,785
1904	996,456	29,504	0.03	6,391,566	226,481	0.03½	7,388,022	255,988
1905	1,545,400	50,225	0.03¼	6,444,083	219,198	0.03⅜	7,989,483	269,425
1906	1,663,000	83,150	0.05	7,639,507	336,609	0.04½	9,302,507	419,753
1907	2,020,000	101,000	0.05	9,922,870	553,440	0.05½	11,942,870	654,449
1908	2,603,505	99,193	0.03⅛	9,592,881	417,137	0.04⅜	12,196,387	516,330
1909	2,015,880	57,957	0.02⅞	7,183,644	272,493	0.03⅞	9,199,524	330,450
1910	2,652,000	66,300	0.02½	8,204,123	250,115	0.03	10,856,123	316,410
1911	6,162,000	123,240	0.02	6,916,069	203,766	0.02¾	13,078,069	327,006
1912	6,282,000	190,757	0.03⅛	6,205,562	200,616	0.03¼	12,487,562	391,373
1913	4,750,000	142,340	0.03	5,164,768	223,525	0.04⅓	9,914,768	365,865

The sources of supply have apparently been gradually restricted, Canada which, in recent years, had increased its output of this commodity.

did not offer it so freely. Shipments from Mexico were interfered with by the political conditions there and arrivals during the latter half of the year were practically nil; the Cia. Minera de Peñoles, the only producer of importance, was compelled to close its plant at Mapimí. Germany, England and Spain sent only moderate quantities to this country.

The situation seems therefore to be that the American manufacturers of arsenic have now this market in hand, and probably are determined to retain their position in it. The interior consumer was naturally supplied to greater advantage from the producers in Utah, Colorado and Montana, than he could be by the importers at the Eastern seaboard. A crude-arsenic plant was constructed in 1913 at the Great Falls smelting works of the Anaconda Copper Mining Co., the product being sent to its Washoe works for refining. The high purity and satisfactory quality of the American arsenic has, moreover, firmly established its reputation among users. Hence, it seems safe to say that unless an extraordinary demand shoud come from quarters of which the trade is not now cognizant, the arsenic of American manufacture will be amply able to take care of the consumption in this country, and perhaps eventually, instead of being an article of import, arsenic may prove to be one for which a market must be sought outside of our own boundaries. The production of white arsenic in the United States in 1913 was 2312 tons, as against 2926 tons in 1912 and 3081 tons in the preceding year.

The Arsenic Market in 1913[1].—The course of the arsenic market in 1913 plainly showed that the claims of those rampant bulls in 1906 that the demand for arsenic would exceed the supply of the world were as ill founded as the bearish news of two years ago, when it was stated that the enforced output of arsenic in this country would prevent the price ever again reaching a reasonable figure. The price tended to establish itself in equilibrium between the high figure of 12 cents per pound and the low figure of 1 1/2 cents per pound in the previous few years.

The high price of 1913 was made in January, when arsenic sold at 4 cents. From that time until the last of August a slow and steady decline took place, each month seeing the market down about 1/8 cent per pound until 3 cents was reached. After August the market was extremely dull and steady at this figure. Demand was about sufficient to take up supplies as they came forward, and sellers did not, on the other hand, attempt to force the situation.

Uses of Arsenic.—White arsenic is used principally in glass making and in the manufacture of Paris green, lead arsenate, and other insecticides. With the growth of horticulture and the necessarily greater attention paid to killing insect pests, the demand for arsenical insecti-

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

cides has grown immensely. Experiments conducted by a number of the state agricultural experiment stations have demonstrated the value of arsenic when combined with lime as an effective spray against insect pests, while arsenic solutions have been found of considerable value when used as a dip for cattle and sheep.

A number of arsenic salts and oxides are used medicinally, among them the bromide, iodide, trisulphide, trioxide, sodium arsenate, and potassium arsenate. Disulphide of arsenic, both natural and artificial, is used as a paint pigment; in calico printing and dyeing; in tanning; and, as it burns with an intense white light, in fireworks. Orpiment, the trisulphide, called also king's yellow, is used as a paint pigment and as a reducing agent in chemical work. The trioxide is used in paints; for preserving hides, both for taxidermists and in the leather industry; as an antiseptic; and in killing animal pests. Sodium arsenate is used in dyeing with turkey-red oil and in printing fabrics; the arsenite in making soaps for use on skins and hides. Potassium arsenite is used as a reducer for silver in the manufacture of mirrors.

WORLD'S PRODUCTION OF ARSENIC.
(In metric tons.)

Year.	Canada. (a)	Germany. (b)	Italy. (d)	Japan. (a)	Portugal. (d)	Spain. (b)	United Kingdom. (a)	United States. (a)	France. (d)
1898.....	*Nil.*	2,677	215	7	751	111	4,241	.....	.....
1899.....	52	2,423	304	5	1,083	101	3,890	.....	2,600
1900.....	275	2,414	120	5	1,031	150	4,146	.....	4,705
1901.....	630	2,549	.....	10	527	120	3,416	272	7,491
1902.....	726	2,828	.....	12	736	71	2,165	1,226	5,372
1903	233	2,768	50	6	698	1,088	916	554	6,658
1904.....	66	2,829	80	4	1,370	400	992	452	3,117
1905.....	*Nil.*	2,535	.....	8	1,562	1,140	1,552	701	3,627
1906.....	*Nil.*	3,052	.. ..	5	1,322	1,114	1,625	754	6,534
1907.....	317	2,904	73	7	1,538	2,400	1,523	916	7,900
1908.....	649	2,822	451	20	1,655	2,004	2,007	1,301	2,381
1909.....	1,020	2,911	*Nil.*	8	1,420	506	2,911	914	2,141
1910.....	1,363	3,066	*Nil.*	12	974	444	2,187	1,203	8,045
1911.....	1,815	2,981	16	6	887	331	2,178	2,800	19,000
1912.....	1,858	4,869	*Nil.*	.....	1,006	(c)	2,228	2,855	81,880
1913.....	1,538	.....	.....	.....	.....	.....	.....	2,158	.....

(a) White arsenic. (b) Oxide, sulphide, etc. (c) Not yet available. (d) Ore.

BIBLIOGRAPHY

BLASSETT, E., JR.—Arsenic as an Agent in Metal Coloring. *Metal Ind.*, **11**, 124–5.

ELTON, J. O.—Arsenic Trioxid from Flue Dust. *Bull. A. I. M. E.*, No. 80, 1497–1509.

HESS, F. L.—Production of Antimony, Arsenic, Bismuth, and Selenium in 1912. *Min. Res. of U. S.*, 1912.

MILLER, W. G.—The Cobalt Area, Ontario, *Can. Min. Jour.*, Sept. 1, Sept. 15, 1913.

TOOMBS, C.—Arsenic in Sheet Zinc. *Jour. Chem. Met. So. Afr.*, **13**, 407.

ASBESTOS

By Edward K. Judd

The chief features of the asbestos industry during 1913 were a general recovery from the depressed condition of 1912, induced by overproduction during the year before, and a pronounced growth in the demand for the product, of both crude and mill grades. All the larger producers began, in 1913, to operate on more extended scales, by making additions to equipment for both mining and milling. Many of the smaller concerns are still laboring under financial difficulties, resulting usually from excessive bonded indebtedness and other fixed charges. Considering that not more than 6 per cent. of the rock excavated can be converted into marketable product, of any grade, and that great expenditure of time and capital is required to prepare a given asbestos deposit for commercial exploitation, it is not surprising that only the strongest concerns are at present operating profitably.

ASBESTOS STATISTICS OF THE UNITED STATES

Year.	Production.			Imports.		
	Short Tons.	Value.	Value per Ton.	Manufactured.	Unmanufactured.	Total.
1900	1,100	$16,500	$15.00	$24,155	$331,796	$355,951
1901	747	13,498	18.08	24,741	667,087	691,828
1902	1,010	12,400	12.27	33,313	729,421	762,734
1903	(a) 887	(a)16,760	(a)18.90	32,058	657,269	689,327
1904	(a)1,480	(a)25,740	(a)17.40	51,290	700,572	751,862
1905	3,100	126,300	40.74	70,117	776,362	846,479
1906	(a)1,695	(a)28,565	(a)16.85	96,162	1,010,453	1,106,615
1907	950	11,700	12.32	200,371	1,104,110	1,304,481
1908	1,350	24,000	17.78	147,548	1,068,342	1,215,890
1909	4,025	87,625	21.77	240,381	993,254	1,233,635
1910	3,630	64,350	18.80	308,078	1,235,170	1,543,248
1911	(a)7,604	(a)119,935	(a)15.77	290,098	1,413,541	1,703,639
1912	(a)4,403	87,959	19.97	363,759	1,456,012	1,819,771
1913	(a)1,100	11,000	10.00	389,664	1,928,705	1,329,369

(a) Statistics of the United States Geological Survey.

The market demand for asbestos during 1913 showed increasing strength, due to growth in the older consuming industries as well as to the development of new fields of application. Increasing demand was most pronounced in the case of the higher grades of crude fiber, although the various cheaper grades of short fiber were also in large request, being of increasing value in the preparation of plaster, stucco, and other structual materials. Asbestos cement is growing in favor. Plaster containing asbestos is not only more resistant to fire, but forms a more nearly soundproof material, and possesses acoustic properties which adapt it for use on the walls of auditoriums which might otherwise suffer from the presence of echoes. Shingles of asbestos cement are a relatively recent application.

A new concern, the National Asbestos Shingle Corporation, of New York, is about to begin the manufacture of asbestos shingles having a tapering shape, produced under German patents, instead of a uniform thickness, which is the form in which it has heretofore been customary to make these shingles.

Prices early in 1914 averaged as follows, per short ton: Crude No. 1, $350; crude No. 2, $200; spinning fiber, $125; shingle stock, $55; paper stock, $25; cement fiber, $15; air-floated asbestos powder, $7.50 per ton. The last-mentioned product is made in great abundance by all the mills, and is used as a paint filler, for flooring compositions, and in plaster and stucco.

In 1913 the United States exported manufactured asbestos valued at $763,949.

Africa.—The December returns of the Mines Department of the Union of South Africa shows a production of 76 short tons of asbestos.

Canada.—This country now contributes over 80 per cent. of the world's production of asbestos, and provides nearly all of that material consumed in the United States. The industry centers in the eastern townships of Quebec Province. The active operators in 1913 were the following:

Asbestos Corporation of Canada.	Two mines, three mills..	Thetford Mines.
Asbestos Corporation of Canada.	Three mines, three mills.	Black Lake.
Black Lake Chrome and Asbestos Co		Black Lake.
Jacobs Asbestos Mining Co		Thetford Mines.
Johnson Asbestos Co		Thetford Mines.
Martin-Bennett Asbestos Co		Thetford Mines.
Bell Asbestos Co		Thetford Mines.
B. & A. Co		Robertsonville.
Asbestos and Asbestic Co		Danville.

The Asbestos Corporation is much the largest producer; its King No. 1 crude is recognized as the highest standard of asbestos produced in the district. The company also produces four other grades of No. 1 crude fiber. The whole output of the Bell Asbestos Co., is consumed by Keasby & Mattison, and that of the Asbestos & Asbestic Co., by H. W. Johns-Manville Co.; the latter firm also buys part of the output of other mines.

None of the quarries formerly worked at East Broughton were in operation in 1913, although one concern made small shipments from stock.

According to the preliminary report (subject to revision) of the Canadian Bureau of Mines, the output and shipments in 1913 exceeded those of all previous years, the increase in sales over 1912 being 22.75 per cent. The total output in 1913 was 132,564 tons, against 102,759 tons in 1912, an increase of 29,805 tons or 29 per cent. Sales and shipments of asbestos fiber in 1913 were 136,951 tons, valued at $3,830,909, or an average of $27.97 per ton, as against sales in 1912 of 111,561 tons valued at $3,117,572,

or an average of $27.95. Stock on hand on Dec. 31, 1913, was reported as 20,786 tons, compared with stocks of 23,288 tons at the beginning of the year.

The number of men employed in mines and mills was 2951 and the amount paid in wages $1,687,957.

The total quantity of asbestos rock sent to mills is reported as 2,110,990 tons, which, with a mill production of 127,539 tons, shows an average estimated contents of about 6.04 per cent. of fiber in the rock.

The output and sales of crude and mill stock separately is shown for 1912 and 1913 in tabulated statements following. The classification is based on valuation, crude No. 1, comprising material valued at $200 and upward per ton, and crude No. 2, under $200; mill stock No. 1 includes mill fiber valued from $30 upward, No. 2, from $15 to $30, and No. 3, under $15.

The total sales of crude in 1913 were 5660.3 tons, valued at $989,162, or an average of $174.75, against sales in 1912 of 5662.9 tons valued at $890,351, or an average of $157.22, practically the same quantity but at a higher average price.

The total sales of mill stock in 1913 were 131,291 tons valued at $2,841,747, or an average of $21.64 per ton, against 105,898 tons in 1912, valued at $2,227,221, or an average of $21.03 per ton, a large increase in quantity but at substantially the same average price.

There was a falling off in the amount of both crude and mill fiber in stock at the end of the year.

CANADIAN OUTPUT, SALES, AND STOCKS IN 1913.
(Subject to revision.)

	Output.	Sales.			Stock on Hand Dec. 31.		
	Tons.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton
			$	$		$	$
Crude No. 1	2,015	1,853	531,200	286.62	880	247,877	281.52
Crude No. 2	3,010	3,807	457,962	120.29	1,522	178,789	117.47
Mill stock No. 1	23,444	26,198	1,229,908	46.95	6,755	350,165	51.84
Mill stock No. 2	58,592	60,164	1,201,215	19.97	4,809	108,285	22.52
Mill stock No. 3	45,503	44,929	410,624	9.14	6,820	54,604	8.01
Total asbestos	132,564	136,951	3,830,909	27.97	20,786	939,720	45.21
Asbestic	.....	24,135	19,016	0.79	.....	.....	.....

Exports of asbestos during the calendar year 1913 were 103,812 short tons, valued at $2,848,047, compared with 88,008 tons valued at $2,349,-353 exported during 1912. During 1913, asbestos manufactures were exported to the value of $73,446.

According to R. E. Hore (*Can. Min. Jour.*, Oct. 15, 1913), the asbestos occurs in thin irregular veins traversing masses of serpentine. The veins

are seldom more than 2 or 3 in. thick, though occasionally they are 5 or 6 in. thick for short distances. The asbestos is of the chrysotile variety. It is finely fibrous and has a silk-like luster. The fibers lie transversely to the walls of the vein and hence are of limited length. Frequently the fibers extend from wall to wall; commonly, however, there is a parting in the vein, and then the fibers are even shorter, extending from the parting to both walls.

As the thin veins traverse the rock in all directions, and do not continue for great distances, it has not been found possible to mine the veins individually. The practice is to break the rock containing veins and then sort out the asbestos from the waste rock. Usually the veins are not confined to a narrow zone. Hence the mine openings are large and it has been found advisable to do most of the mining, or quarrying, in open cuts. At one property some underground work has been done, but most of the production is from open cuts. Production, therefore, varies with the weather; in winter, comparatively little work is done. When the overburden has been removed the rock is broken in benches by dynamite. Machine drills are used in most of the mines, but hand drilling is the practice at some of the smaller properties. The broken rock is sorted and the best quality of asbestos, known as long fiber, is picked out by hand. Rock containing short fiber, and all the fine material, are sent to the mill. The remaining rock is piled on waste dumps. Cable derricks are used to hoist the ore from the pits.

At the mills the higher-grade mine product is broken by hand, with heavy hammers. The fiber thus separated from the rock is cleaned by girls using smaller hammers. The product from hand-cobbing is the asbestos known as 'crude' and is ready for the market. The discards from the cobbing sheds, and the rock sent directly from the mine to the mill, are treated mechanically. The material is first dried by exposure to the air, by steam pipes, or in rotary dryers. The rock is then first crushed in jaw or gyratory rock-breakers, and then by rolls or in machines known as fiberizers and cyclones. The material from these machines falls on a screen whence the fiber is picked up by suction produced by a fan. The fiber is then classified by treatment on grading screens into long and short fiber.

China.—U. S. Consul Baker, of Antung, China, states that valuable deposits of asbestos have been found in the vicinity of Kuantien, a small town lying about 45 miles northeast of Antung. The product appears to be of good quality. The price at Antung is about 60 cents U. S. currency, per pound, but as the mining is done in a desultory and primitive manner, the cost could be greatly reduced by using modern machinery. Three mines are now in operation, each employing about 30 workers. These

are mostly farmers who devote only their spare time to mining, using merely hammers and chisels, and gather only the asbestos which lies near the surface.

Russia.—The asbestos deposits of the Urals are found mainly on the eastern slope, and although they are known to stretch over a great area, beginning in the Bogosloff district in the north, at present the mineral is mostly exploited at the asbestos mines situated close to Ekaterinburg on the Kamensk government estate, and elsewhere. Owing to the strong present industrial demand for asbestos the production has been on the increase from year to year, and in 1912, compared with 1907, *i.e.*, in the space of 5 years, the production had doubled. The producing concerns in 1912 were: A. Ph. Poklievski Korell Successors, 324,279 poods; Baron E. A. Zihirar de Sukanton, 323,335 poods; P. O. Korievo Successors, 221,470 poods; the Italo-Russian Asbestos Co., 70,125 poods, and the M. V. Muchanoff Co., 68,470 poods. (1 pood = 36.11 lb. av.).

The price of asbestos at the mine is 2 roubles to 2 roubles 20 copecks per pood. ($55.50 @ 61.05 per ton.) Most of it is exported; for example, the asbestos from the Italo-Russian works is sent to Italy to be manufactured. Twenty asbestos mines or quarries were being exploited in 1912, and these employed 4194 workmen, which means an average production of 250 poods per man.

The asbestos produced in the Urals in recent years has been as follows: 1903—321,364 poods; 1904—457,981 poods; 1905—443,619 poods; 1906—489,700 poods; 1907—541,143 poods; 1908—663,038 poods; 1909—814,134 poods; 1910—677,966 poods; 1911—948,380 poods, 1912—1,007,679 poods. Thus the total production of asbestos in the Urals during the past 10 years has been 6,365,004 poods.

Asbestos was discovered in the Urals as far back as 1720, on the river Tagil, on Nikita Demidoff's estate. Since that time asbestos has been mined and manufactured on the spot in small quantities, almost entirely at the Neviansk factory. The art of preparing asbestos yarn became well advanced long ago, as may be seen in the samples shown in the museums, which show asbestos goods made at the Neviansk works, where the art of weaving the yarn was discovered quite independently. But as there was not much market for it, the industry was practically abandoned. It was taken up again seriously in 1889, reached the level of 321,364 poods in 1903, and the record figure of 1,007,679 poods in 1912.

The recently organized Perm Province Asbestos Syndicate includes the following concerns: The Vosnisensk Asbestos Mines, Heirs of Yakovlev, Heirs of Kosol, Korova Asbestos Mines, Girar de Sukanton, and the Russo-Italian Society for Asbestos Industry. The estimated annual production of the syndicate is 18,540 short tons.

South Africa.—Considerable interest is again being taken in the asbestos deposits of the Transvaal and Rhodesia, and it is interesting to note that both in the Umswezwe district of Mashonaland and the Carolina area of the Transvaal, much activity prevails on the asbestos fields. About 4 years ago the Carolina Asbestos Co. suspended all operations on the farm Diepegezicht, operations having proved unprofitable. Recently, however, certain British asbestos merchants have entered into an agreement for operating the property on a tributing basis.

Natal.—The discovery of a promising asbestos deposit has been reported, and a company, registed as the African Asbestos Co. (Ltd). having a nominal capital of $58,400, has been organized to work the field. The locality is an oblong plateau 2 by 4 miles, situated in the Klip river division, western part of Natal. The fibrous zones at the outcrop are 12 to 14 in., but rapidly widen, and at 12 ft. from the surface are 24 in. The only seam that has so far been exposed to a greater depth is 4 ft. 9 in. across its face at the 30-ft. level. The asbestos is inclined to brittleness. The deposit is about 40 miles from the railroad, but in a region where labor is plentiful. The commercial value of the asbestos is not yet ascertained.

West Australia.—The Geological Survey has issued a recent report by Torrington Blatchford on the asbestos deposits at Soanesville, in the Pilbarra goldfield. The rocks here are serpentine, which has been intruded by dolerite dykes. Asbestos has been found in several places within the area, but only two exposures have been prospected to any extent. Locally these deposits are known as the "A" and "B" lodes. In the "A" deposit the fiber is short, and fit only for mill treatment. On the "B" lode, which has been developed to a depth of 149 ft. some excellent asbestos has been exposed, but apparently the deposit is narrow. The total cost of producing the marketable product at Pilbarra and putting it on a local or foreign market, including labor of mining, cobbing and bagging, transport, etc., would probably not exceed £20 per ton. There is, therefore, a good margin of profit in working good crude fiber. In estimating the value of milling fiber, the difficulties are many. The average Canadian price of all grades of mill fiber is £6 per ton. Taking the asbestos veins as they stand exposed in the workings, and making due allowance for high mining costs under existing conditions, it would cost at least 20s. per ton to mine and mill the asbestos rock on the spot. Assuming a recovery of fiber and milling rock amounting to 20 per cent., this would mean a cost of £5 to produce 1 ton of mill fiber, exclusive of cartage, freight, realization charges, etc. The shipments of asbestos thus far amount to 40 tons, valued at $1600, sold in 1908, and 283 tons, valued at £154 sold in 1909.

ASPHALT

Asphalt is one of the solid native bitumens, which are composed of hydrocarbons. It melts readily with heat and is soluble in turpentine, chloroform, carbon disulphide and similar solvents and in heavy petroleum oils. Residual pitches prepared from asphaltic or semi-asphaltic petroleums by industrial processes are also termed asphalts. Owing to the different kinds of petroleum in which they originate, they are of a very varied character, and not uniform.

The supply of native asphalt comes chiefly from Trinidad and Venezuela, and the industry has increased each year. The production in the United States is given in the following table:

PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN THE UNITED STATES. (a)
(Tons of 2000 lb.)

States.	1910.			1911.			1912.		
	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
Bituminous Rock.									
California	37,547	$128,212	$3.45	27,507	$89,264	$3.25	35,637	$88,621	$2.50
Kentucky	9,938	53,703	5.40	15,831	54,980	3.70	.....	.....	.....
Oklahoma (c)	11,959	65,244	5.46	.....	.....	.....	10,969	44,428	4.05
Texas	.....	.....	.....	.....	.....	.....	6,435	19,626	3.05
Utah	5,110	153,398	30.00	.....	.....	.....	.....	.....	.....
Total	64,554	$400,557	(g) $6.20	41,338	$144,244	$3.50	53,041	$152,675	$2.87
Asphaltum (b)									
California	105,463	1,204,854	11.42	177,690	2,202,490	12.40	213,694	2,097,782	9.85
Oklahoma (c)	.....	.....	.....	53,566	325,976	6.09	54,748	296 945	5.40
Utah	755	43,035	57.00	.....	.....	.....	.....	.....	.....
Texas	57,713	1,040,825	18.07	55,826	786,785	14.05	88,097	1,384,640	15.75
Total Asphaltum	163,931	$2,288,714	(g) $12.47	287,082	$3,315,251	$11.55	356,539	$3,779,367	
Gilsonite (d)									
Utah	29,832	372,900	12.47	30,846	516,614	16.70	39,930	688,689	17.25
Oklahoma (c)	.....	.....	.....	5,000	15,000	3.00	.....	.....	.....
Mastic									
California	476	5,670	11.90	.....	.....	.....	.....	.....	.....
Kentucky	1,287	12,226	9.50	.....	.....	.....	.....	.....	.....

(a) From the Mineral Resources of the United States. (b) Includes hard and refined, or gum, liquid or maltha, and oil residues. (c) Indian Territory included before amalgamation into one State (d) Includes gilsonite, elaterite, grahamite, ozokerite, and "tabbyite." (g) Average value per ton.

The net imports of asphalt and bitumens into the U. S. were: 1910 166,375 long tons; 1911, 174,234 tons; 1912, 194,775 tons; 1913, 193,783 tons, valued respectively $4.65, $4.47, $4.72 and $4.71 per long ton.

The exports of asphalt were as follows: in 1911, unmanufactured, 16,925 tons, valued at $360,708, and manufactures valued at $238,222; in 1912, unmanufactured, 39,915 tons, valued at $886,678, and manufac-

tures valued at $467,959; in 1913, unmanufactured, 58,440 tons, valued at $1,267,625, and manufactures valued at $411,786.

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK. (a)
(In metric tons.)

Asphalt.

Year.	France.	Germany.	Hungary.	Italy. (c)	Spain.	Trinidad. (b)	United States.	Total.
1904...	22,000	91,736	2221	34,227	3463	137,089	77,250	367,986
1905...	20,000	115,267	247	26,838	5805	116,735	68,935	353,827
1906...	28,231	138,059	4111	34,386	6229	132,381	94,316	437,713
1907...	33,000	126,649	3920	38,568	8643	147,051	161,783	519,614
1908...	41,000	89,009	4818	34,761	9231	136,583	134,273	449,675
1909...	44,800	77,537	5054	39,165	6582	146,013	126,530	445,681
1910...	38,500	81,208	4994	41,705	8473	161,587	148,760	485,227
1911...	38,000	81,902	3861	50,179	3495	163,080	260,510	601,027
1912...	31,535	96,112	4460	52,747	5387	176,077	359,597	725,915
1913...	.....	.....	.....	.....	.....	208,164	.....	.....

[1] MINERAL INDUSTRY, XX, p. 75.

Bituminous Rock.

Year.	Austria.	France.	Hungary.	Italy.	Spain.	United States.	Total.
1904.....	1435	277,000	17,660	111,390	3,761	19,454	380,700
1905.....	4363	191,509	19,372	106,586	5,725	32,337	359,892
1906.....	2840	196,375	34,664	130,825	7,794	21,848	394,348
1907.....	3858	177,000	33,096	161,126	8,219	41,301	424,600
1908.....	3695	171,000	72,972	134,163	12,373	33,901	428,104
1909.....	2975	169,000	(d)70,000	111,067	5,284	50,243	408,569
1910.....	1066	170,000	(d)70,000	162,212	7,795	58,581	654,649
1911.....	1740	169,697	.....	188,133	6,500	37,512	.....
1912.....	4234	280,313	.....	181,397	.....	48,108	.....
1913.....	3026	.....	.....	.....	.....	.....	.....

(a) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland, and Venezuela are not available. (b) Exports. (c) Including mastic and bitumen. (d) Estimated.

BIBLIOGRAPHY

DARBY, A.—Natural Rock Asphalts and Bitumens. London, Constable & Co.

DAY, DAVID T.—The Production of Asphalt, Related Bitumens, and Bituminous Rock in 1912. *Min. Res. of U. S.*, 1912, *U. S. Geol. Surv.*

FINLEY, W. H.—Asphalt Waterproofing. *Eng. Mag.*, 44, 113–5.

FRENTZEL, ALEXANDER.—Die Erdol, Bitumen und Schwefellager von Tetjuschi. *Petroleum*, June 4, 1913, p. 1121.

GRAEFE, ED.—Der Asphaltsee auf der Insel Trinidad und die Verwertung des Trinidad-asphaltes. From *Zeit. angew. Chemie. Bergbau*, June 12, 1913, p. 391.

ITALIAN GAS SOCIETY OF TURIN.—Dry Distillation of Natural Sicilian Asphalt and Bitumen. *Ind. chim.*, 13, 103.

KANTOROWICZ, H.—Ueber Erdol und Erdwachs. *Chemiker Ztg.*, Nov. 13, 1913, p. 1394.

KNAPP, I. N.—Natural Gas, with Incidental Reference to other Bitumens. *Jour. Frank. Inst.*, Dec., 1912; *Nat. Gas Jour.*, Jan., 1913, p. 15.

LAW, LEROY M.—Empirical Requirements in Asphalt Specifications. *Jour. Ind. Eng. Chem.*, Dec., 1913, p. 1021.

MARCUSSON, F.—Chemical Constitution and Differentiation between Natural and Artificial Asphalts. *Mitt. kgl. Materials-prufungsampt*, 30, 2; *Farben Ztg.*, 17, 2535.

PECKHAM, S. F.—The Asphaltic Rocks of the United States and their Uses in Street Paving. *Trans. Am. Inst. Chem. Eng.*, 5, 245.

PIETRUSKY, K.—The Asphalt Industry of the U. S. *Chem. Ind.*, 36, 225–8.

RAEFLER, F.—Das Bitumen in der Zeitzer Braunkohle. *Zeit. prakt. Geol.*, Nov., Dec., 1912, p. 483.

RAKUSIN, M. A.—Ueber des Elaterite aus dem Gebiet Semirjetschensk. *Petroleum*, March 5, 1913, p. 729.

RICHARDSON, C.—Characteristics and Differentiation of Native Bitumens and their Residues. *Jour. Ind. Eng. Chem.*, June, 1913, p. 462; *Eng. Rec.*, 67, 466–8.

SCHAAY, J. H.—Notes upon the Bitumen-bearing Sandstones of Western Switzerland. *Zeit. prakt. Geol.*, 20, 488–90.

SNIDER, L. C.—The Oklahoma Rock Asphalts and their Use in Paving. *Good Roads*, 5, 158–60; *Min. Eng. World*, Mar. 22, 1913, p. 577.

STRAHL, G.—Asphalt. *Montan Ztg.*, May 1, 1913, p. 165.

THIELE, F. C.—Ueber Saureasphalt von der Erdolreinigung. *Chemiker Ztg.*, July 15, 1913, p. 84.

TRUMP, I. V.—Testing Bitumens. *Eng. Contr.*, 38, 635.

TRUMP, I. V.—Der Asphaltsee auf der Insel Trinidad und die Verwertung des Trinidad Asphaltes. *Bitumen*, June 16, July 1, 1913.

TRUMP, I. V.—The Bitumen of the Falkland Islands. *Petroleum Rev.*, 27, 304.

BARYTES

By A. H. Reed

In 1913 the principal domestic production of barytes has come from the Missouri and from the Appalachian districts, as it has for several years. The Kentucky Geological Survey estimates that the barytes deposits of eastern Kentucky are the largest in the United States; and there are several large deposits of barytes known in the fluorspar district of western Kentucky. And more than one large vein of barytes has been discovered in the Rocky mountain region of the United States.

The barytes industry is a considerable one, as can be seen by a glance at the following world statistics.

PRINCIPAL COUNTRIES IN WHICH BARYTES IS PRODUCED.
(Metric tons.)

	1909.	1910.	1911.	1912.	1913.
Austria-Hungary (exports)					
Barium chloride	3,737	4,344	3,741	3,659	4918
Barytes	2,585	13	12	2,690	753
Belgium (production)	31,400	4,960	25,200	32,400	12,000
Canada (production)	*Nil.*	*Nil.*	50	421	582
France (production)	14,111	11,632	10,064	13,620	.....
Baden (production)	15,186	13,832	15,014	15,871	16,445
Bavaria (production)	17,920	24,711	26,234	27,199	27,199
Germany (exports)					
Barytes	90,555	114,264	128,452	142,681	158,065
Barium white	4,888	5,528	6,834	8,242	7,647
Barium chloride	5,340	6,403	6,180	8,096	5,649
Barytes (imports)	14,560	5,782	7,926	18,666	19,466
Italy (production)					
Barytes, ground	1,950	.....	.....	.....	.....
Barytes, crude	16,240	14,420	13,620	.....	.....
Barytes (imports)	2,094	1,777	2,024	1,986	1,761
Barytes (exports)	125	150	353	381	234
Spain (production)	422	476	635	1,096	.....
Sweden (imports)	529	625	607	644	610
United Kingdom (production)	42,436	43,637	43,232	43,453	.....
United States (imports)	13,301	22,536	21,195	27,093	36,878
United States (production)	56,211	38,998	34,887	[34,009	41,105

The Missouri district affords two kinds of deposits of the mineral. (1) An initially high grade of barytes, found mainly in Washington County, that is residual in clay, and so is not susceptible to the laying out of systematic and durable mines, and the mining of which is typified by gophering on a contract basis, although the Point Milling & Mfg. Co., has installed recently a small steam shovel on their barytes property, to do the work of stripping and mining. As much as 95 per cent. of the Missouri production has come in past years from Washington County, but this great preponderance of production by one county has been lowered

during the past year by the advent of considerable proportionate production from some other counties, which have generally another class of ore. (2) A lower grade of barytes, initially, occurring more or less as a vein that has other mineral associations, as lead and zinc, calcite and gangue, and which class of ore has to be dressed and freed from impurities and concentrated. This form of deposit is adaptable to systematic mine exploitation, and a few orderly barytes mines have been developed in some favorable localities of economic occurrence of this type of ore. Usually milling will give by-products of either lead or zinc, although barytes itself is a secondary product at some mines and mills.

In Cole and in Benton Counties, Mo., barytes occur contaminated with lead and zinc. Near Henley, Cole County, the Bryant Barytes-Lead Mining Co. is operating a new concentrating plant, treating mainly old dumps, and also operating an open-pit mine. Nearby, about a mile south, a similar interest, the Bryant Mining Co., is operating Franck mine, another open pit, and is concentrating barytes by sluice washing and hand jigging. The combined production of these two operations is about 50 tons daily of high-grade barytes concentrates. The Fink Mining Co. is operating Wilson mine, south of and adjacent to Franck mine, and by the practice of sun-drying, hacking and "rattling" has managed to keep up a production of 10 to 15 tons daily of good barytes. Tahoma mine, in Benton County, Mo., affords a barite-blende ore, which is being successfully treated by process of decrepitation, after preliminary jigging and partial drying.

And since the mechanical features of decrepitation have been worked out successfully at Tahoma mine, other mine operators having a similar barite-blende ore have been encouraged to adopt the process. Black Jack Mining Co., Bass, Cole County, Mo., however, was not able to use the decrepitation process on account of the failure of their ore to behave under the process as it should, but the Huff electrostatic process has been successfully adapted to treat the Black Jack mine ore.

Barytes as a secondary product is recovered also by milling processes from galena-barite ore, occurring in fissure vein conditions, in Franklin County, Mo., and a new mill lately constructed by the Wrisberg Mining & Milling Co., is reported to have had a successful year in 1913, in mining and dressing this class of ore.

The principal operators in Washington County, Mo., are Potosi Lead, Barytes and Mercantile Co., Potosi, Mo., producing 40 to 50 tons of barytes daily; and Point Milling & Mfg. Co., Mineral Point, Mo., producing 8 to 10 tons of barytes daily. The combined production of all other barytes diggings in the Potosi-Mineral Point district of Washington County, Mo., will average perhaps as much as 10 tons of barytes daily.

Nulsen, Klein & Krause Mfg. Co. have a grinding, preparation and chemical products plant at St. Louis. J. C. Finck Mineral Milling Co. have a mill at Wickes, Mo., and also at St. Louis, at which latter plant grinding, bleaching and preparation of barytes is done. The Point Milling & Mfg. Co., has a large finishing and preparation plant for barytes, at Mineral Point, Mo. And the Illinois Mineral Milling Co., grinds barytes in a plant located at East St. Louis, Illinois.

The Appalachian barytes field includes the following localities: Cartersville, Ga.; Stackhouse, N. C.; Sweetwater, Tenn.; and twc areas in Virginia. The deposits in these sections are, in the main, residual in clay, and are mined by open pits methods. In some of the workings initially high-grade barytes is often obtained, which, when thoroughly washed, may be marketed direct, either crude, or ground, in either case without mill concentration. However, a great deal of the barytes mined in the Appalachian district is contaminated with chert, principally, or is cellular in character, having the cellular spaces filled with clay, and therefore has to be milled and concentrated. The deposits in North Carolina and the Piedmont deposits of Virginia are characterized by more or less vein conditions of deposition, and are mined by underground methods from shafts and slopes.

There was very fair activity in the Appalachian region, in 1913, although some of the principal operators in the past did not operate at all during the year. Carolina Barytes Co., main office 100 William Street, New York City, was perhaps the most prominent single operator. This interest operates mines and also a mill at Stackhouse, N. C.; contracts for and buys barytes at Sweetwater, Tenn. which product is now shipped to Stackhouse for milling; and during the past year acquired the Nicholasville, Ky. barytes plant, to which up to October and November, 1913, Sweetwater product was shipped for milling. Other important operators are B. W. Gahagan, at Stackhouse, and Hot Springs Mfg. Co., Hot Springs, N. C. In Tennessee, the Lookout Point Mfg. Co. is operating a finishing and chemical products plant at Chattanooga; the Gilman Barytes plant at Sweetwater, built to treat the ore and also to manufacture barium compounds, has been idle during the year, and the operating company is in the hands of receivers who have advertised the plant for sale; and the Commercial Mining & Milling Co., Knoxville, has reported little activity in their business during the year. John T. Williams & Son, Bristol, Va., are reported as having re-organized their barytes business into the Virginia Zinc & Chemical Corporation, and propose to continue treating barytes and manufacturing barium compounds. There are many good barytes mines in Virginia, and until late years there were several prominent barytes operators in the state, but reports which have

been received show that there were not more than 2 or 3 concerns active in 1913. Other barytes mills in Virginia are located respectively at Lynchburgh (Nulsen, Klein & Krausse Mfg. Co.); Honaker (Clinch Valley Barytes Co.); and Richlands (Pittsburgh Barytes and Milling Co.).

The barytes deposits of eastern Kentucky are vein deposits, and are more or less contaminated by calcite and by fluorspar, so that milling and concentrating usually is necessary in order to produce commercial barytes. In western Kentucky, the deposits at Mexico are in fissure veins, are sometimes very pure but are frequently accompanied by zinc, lead, calcite and fluorspar, so that successful exploitation of these deposits of barytes may be safeguarded by preparation for milling and concentrating.

New York and St. Louis markets fix the prices on barytes. Imported crude German barytes is generally exceedingly pure, and only requires grinding to make it merchantable; and, because of large cheap production in Germany and low ocean freight rates, notwithstanding there is $1.50 duty on the commodity, german barytes regulates the governing prices in New York. On the other hand, almost all crude domestic barytes, which generally has been concentrated, has to be bleached before grinding. And barytes is used by most of the trade in ground or finely powdered form, crude barytes being scarcely merchantable except to grinding plants that in turn wholesale the ground product, and to chemical products plants that grind the product before using, although very few actual users of ground barytes are fixed to grind the crude material.

Specifications and ruling prices c. i. f. New York, in 1913, were: crude barytes, $5.50 to $6 per ton for product analyzing 96 per cent. $BaSO_4$ and not exceeding 1.5 per cent. SiO_2; with a penalty of 20 cents per ton for each 1 per cent. product would analyze under 96 per cent. $BaSO_4$, and no deliveries acceptable that would analyze less than 92 per cent. $BaSO_4$ or carry more than 1.5 per cent SiO_2. Ground barytes, $18.50 to $24 per ton for white prime foreign; $19 to $20 per ton for domestic Western; $17 to $18 per ton for domestic Southern; and $13 to $15 for off grades.

Extremes of prices quoted for 1913, f. o. b. St. Louis, were: crude barytes, $4.50 to $5.15 per ton for 95 per cent. $BaSO_4$ product; and ground barytes, $8 to $13 per ton, the former price for off grades and the latter for best product.

The following table has been arranged from statistics compiled by U. S. Geological Survey for Mineral Resources, and shows the production of crude barytes in the United States from 1911 to 1913, inclusive, together with the average price per ton, f. o. b. mines, which price is exclusive of cost of wagon haulage, boat or railway freight.

PRODUCTION OF CRUDE BARYTES IN U. S., 1911–1913.
(By states, in short tons.)

State.	1911.			1912.			1913.		
	Quantity.	Value.	Av. Price per Ton.	Quantity.	Value.	Av. Price perTon.	Quantity.	Value.	Av. Price per Ton.
Missouri	21,500	$81,280	$3.79	24,530	$117,035	$4.32	31,131	$117,638	$3.78
Tenn. and Kentucky.	8,819	20,053	2.27	(a) 3,718	8,682	2.34	(a)2,098	3,598	1.70
Other states(a)	8,126	21,359	2.63	9,230	27,796	3.01	12,069	35,069	2.81
Total	38,445	122,792	3.19	37,478	153,313	4.09	45,298	156,275	3.45

(a) Production of Tennessee; no production of barytes reported for Kentucky in 1912 and 1913.
(b) In 1910 and 1912, Georgia, North Carolina, and Virginia; in 1911, Georgia, North Carolina, South Carolina, and Virginia.

IMPORTS OF BARIUM PRODUCTS, 1913.
(Fiscal year, ending June 30.)

Product.	Quantity.	Value.	Declared Value per Unit.
Baryta, sulphate of, or barytes including baryta earth:			
Unmanufactured tons (2240 lb.)	28,358	$63,345	$2.23
Manufactured tons (2240 lb.)	4,594	$36,819	8.01
Blanc fixe, or artificial sulphate of barytes, and satin white, or artificial sulphate of lime, pounds	$4,808,726	58,499	0.012
Zinc, sulphide of, white or white sulphide of (Lithopone), pounds	5,163,642	144,812	0.028
Barium carbonate, pounds	2,182,517	20,143	0.009
Barium binoxide, pounds	3,507,508	215,500	0.061
Barium chloride	2,926,159	26,341	0.009

The uses of barytes are in the manufacture of paints, in preparation of rubber, treating of wall paper, coating of oilcloth and linoleum, glazing of pottery, enameling iron and steel, loading rope, and proofing canvas ham sacks. It is also used in the manufacture of artificial ivory, particularly of poker chips; and is used in the preparation of certain asbestos cements. Its use is advantageous in the manufacture of glass, but little advantage is taken of this adaptation in the United States. Barytes is also the source of manufacture of most of the barium chemical compounds.

BAUXITE

By C. H. Gordon

The mineral bauxite, still practically the only source of the metal aluminium, is a hydrate of alumina, its composition when pure being $Al_2O_3.2H_2O$, or alumina 73.9 per cent. and water 26.1 per cent. As mined the alumina may run as high as 70 per cent. or as low as 40 per cent. Other substances usually present are iron oxide, silica and the oxide of titanium. The ore in the same deposit may show considerable variation in composition.

ANALYSES OF BAUXITE.

No.	Al_2O_3	Fe_2O_3	SiO_2	TiO_2	$CaCO_3$	H_2O	Moisture.
1	30.30	34.90	.....	.....	12.70	22.10	.....
2	55.40	24.80	4.80	3.20	0.20	11.60	.....
3	69.30	*a* 22.90	0.30	3.40	.....	14.10	.....
4	76.90	0.10	2.20	4.00	.....	15.80	.....
5	61.89	1.96	6.01	.....	.....	27.82	.....
6	63.16	23.55	4.15	.....	.....	8.34	.....
7	62.05	1.66	2.00	.....	.....	30.31	3.50
8	87.30	1.43	6.40	3.99	.....	0.88	.....
9	62.46	0.81	4.72	0.23	.....	31.03	.....
10	57.58	0.96	9.38	2.76	.....	29.12	0.35
11	39.92	16.84	20.00	1.47	.....	19.52	1.25
12	61.00	2.20	2.10	.....	.....	31.58	3.12
13	49.90	4.13	*b* 18.38	.....	.....	27.59	.....

a. Includes both FeO and Fe_2O_3. *b*. Insoluble.
1. Hard, compact, red bauxite, Baux, France. 2. d'Allauch, near Marseille, France. 3. Red bauxite from Theronet, Var, France. 4. White bauxite from Villeveyrac, Hérault, France. 5. Glenravel, Ireland. 6. Vochein, Germany. (Includes 0.79 per cent. of alkalies (Na_2O, K_2O). 7. Arkansas. 8. Washed calcined bauxite from Arkansas. 9, 10, 11. Wilkinson County, Georgia. 12. Rock Run, Alabama. 13. Keenburg, Tennessee.

Bauxite may consist of rounded concretionary grains ranging in size from that of a pea up to an inch in diameter, or it may be massive, earthy and clay-like in character. Bauxite melts at 1820° C. and bauxite clay at 1795° C. Bricks made from unrefined bauxite ore melt at 1740° C.[1]

Alumina occurs in the anhydrous form practically pure in the mineral corundum, but this substance is too valuable and occurs in insufficient quantity to be available as an ore of aluminum.

Bauxite owes its importance chiefly to the large uses of the metal aluminum and to the steady and rapid growth in the demand for the metal. (See article on "Aluminium.") The utility of this metal and the growth of the aluminum industry is so marked that for this use alone the mining of bauxite is becoming a permanent industry while the prospects for new deposits are promising. There is a steady growth also in

[1] Mineral Industry, xxi, 94 (1912).

the demand for bauxite for refractory uses and for the manufacture of alundum and electric furnace products.

This has resulted in a marked increase in the production of bauxite in the United States during the year 1913, the total output being 210,241 long tons valued at $997,698, an increase of 50,376 or 31.5 per cent. in tonnage and $228,766 or 29.8 per cent. in valuation over the figures for 1912. The states which produced bauxite were as usual Alabama, Arkansas, Georgia and Tennessee. Arkansas is by far the largest producer, this State and Tennessee showing a substantial increase while the production in Georgia and Alabama declined, the decline in the former state being slight but in Alabama considerable.

PRODUCTION OF BAUXITE IN THE UNITED STATES.
(In tons of 2240 lb.)

State.	1903 (a)	1904	1905	1906	1907 (a)	1908 (a)	1909 (a)	1910	1911 (a)	1912 (a)	1913 (a)
Alabama..	22,374	7,087	17,094	27,131	97,776	14,464	22,227	33,096	30,170	19,587	27,409
Georgia...		16,909								14,173	
Arkansas..	25,713	24,016	30,897	51,200	(b)	(b)37,703	(b)106,874	(b)115,836	12 5448	(b)126,105	182,832
Total..	48,087	48,012	47,991	78,331	97,776	52,167	129,101	148,932	155,618	159,865	210,241

(a) Statistics of the United States Geological Survey. (b) Production of Tennessee included.

In the following table is given the figures showing the production, imports, and exports for the United States for seventeen years ending with 1913. The production is largely of crude material and in comparing these figures it must be considered that the shipments are largely of washed and concentrated material and are accordingly less in bulk and tonnage and proportionally higher in value.

STATISTICS OF BAUXITE IN THE UNITED STATES.

Year.	Production.			Imports.		Exports.		Total.	
	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
1897	20,590	$51,475	$2.50	2,645	$10,515	2,537	$5,074	20,708	$56,916
1898	26,791	66,978	2.50	1,201	4,238	1,000	2,000	26,992	69,216
1899	36,813	101,235	2.75	6,666	23,768	2,030	4,567	41,449	12,436
1900	23,445	85,922	3.66	8,656	32,968	1,000	3,000	31,101	115,880
1901	(a)18,905	97,914	4.25	18,313	66,107	1,000	3,000	36,218	144,021
1902	29,222	128,206	4.39	15,790	54,410	Nil.	.....	43,112	175,875
1903	(a)48,087	171,306	3.56	14,889	49,684	Nil.	.....	62,976	220,990
1904	48,012	166,121	3.46	15,475	49,577	Nil.	.....	63,487	215,698
1905	47,991	203,960	4.25	11,726	46,517	Nil.	.....	59,717	250,477
1906	78,331	352,490	(e)4.50	17,809	63,221	Nil.	.....	96,140	415,711
1907	(a)97,776	480,330	4.91	25,065	93,208	Nil.	.....	122,841	573,538
1908	(a)52,167	263,968	5.05	21,679	87,823	Nil.	.....	73,846	351,791
1909	(a)129,101	679,447	5.27	18,689	83,956	Nil.	.....	147,790	763,403
1910	149,679	778,203	5.33	15,720	65,743	Nil.	.....	165,399	843,946
1911	155,618	750,649	4.87	43,222	164,301	7,958	359,837	198,840	914,950
1912	160,124	900,620	5.00	26,214	95,431	10,146	456,581	186,079	864,362
1913	210,241	997,698	4.75	21,456	85,746				

(a) Statistics of the United States Geological Survey. (e) Estimated.

The average values of the crude imported product per ton have been as follows: 1910, $4.18; 1911, $3.80; 1912, $3.65; 1913, $4.00. Practically all the imports of this material are from France.

The conditions under which bauxite occurs are so variable and the knowledge of the methods of its formation so imperfect that as yet prospecting has not advanced very far and there is every reason to believe that many deposits, some of which may differ materially from any now known, remain to be discovered.

Arkansas.—Arkansas stands first among the states in the production of bauxite. The larger part of the production being mined by the American Bauxite Company whose mines are located near the town of Bauxite on the Bauxite and Northern Railway, a spur of the St. Louis, Iron Mountain and Southern Railway which crosses the tracks of the Chicago, Rock Island and Pacific Railway at Bauxite station.

The only other operator in this field was the Republic Mining and Manufacturing Company of Philadelphia, Pa. The National Bauxite Company is reported to have holdings in this field but no operations have been conducted here by this company for several years. A description of the chemical and physical properties of the ore and the geological character of the occurrence were given in MINERAL INDUSTRY, XXI, 88 (1912). The shipments of ore from this field in 1913 amounted to 182,832 tons.

California.—Bauxite exists in southern California, but is not being mined.

Georgia-Alabama Field.—This field covers portions of Cherokee County in northeastern Alabama, and Barton and Floyd counties in northwestern Georgia. The district extends along the Coosa Valley from the vicinity of Summersville or Adairsville, Ga., to Jacksonville, Ala. The deposits occur in residual clay derived from the underlying dolomite or limestones. They occur chiefly in rounded masses several hundred feet in diameter at the surface and tapering to the bottom.

The principal producer in this field is the Republic Mining and Manufacturing Company which operates mines near Rock Run, Cherokee County, Alabama, and in Floyd County, Ga. The mines of the National Bauxite Company which are located in Floyd County, Ga., were idle in 1913. In addition to these are the Cherokee Mining Company and several individual operators in Bartow and Floyd counties, Ga.

Central Georgia Field.—These deposits are located about 30 miles west of Macon in Wilkinson County. They are in no way connected with the deposits of northwest Georgia either geographically or geologically. About 150 miles south of the former field and near the [illegible] plain. The bauxite occurs near the flat contact

between the Tuscaloosa (Lower Cretaceous) and the Claiborne (Tertiary) formations. The bauxite occurs in beds up to 10 ft. thick resting directly upon the Cretaceous clays or disseminated in nodules through the clays. It is found wherever the white clay beds locally known as "chalk-beds" are in contact with the overlying red sands and impure clays.

The ore is hard and generally pisolitic or concretionary though in places it has a dense, halloysitic or even flinty appearance. It varies in color from a creamy white to bright red.[1]

Tennessee.—Bauxite is now being mined in two localities in East Tennessee, on the east side of Missionary Ridge (Sherman Heights) near Chattanooga, and near Keenburg, a station on the Virginia and Southwestern Railroad about 4 miles north of Elizabethton, the county seat of Carter County.

The geological relations of the Chattanooga deposits are similar to those of the northwestern Georgia deposits. They constitute pockets in the residual clays overlying the Knox dolomite, and lie near the fault line along which the dolomite has been overthrust upon the Chickamauga and Clinton formations lying to the northwest. The Keenburg deposits lie nearly 200 miles northeast of the Chattanooga field but in their geologic and structural conditions they are essentially like those of the Sherman Heights area. The ore-body occurs in the form of a large irregular deep pocket inclosed in residual material resulting from the weathering of the Knox dolomite. As similar geological conditions exist all along the east side of the Appalachian Valley other workable bodies are likely to be discovered.

Operations in both areas in 1913 were conducted by the National Bauxite Company of Philadelphia, whose operations during that year were entirely confined to Tennessee. The production in the Chattanooga district was slightly increased and at the same time heavy development work was undertaken to uncover some deep tonnage. The development work which was started about September 1, 1913, consists of heavy stripping operations with a steam shovel to reach a rather large body of high-grade ore which occurs at about 150 ft. in depth and seems to penetrate toward the base of Missionary Ridge. Operations at Keenburg continued at normal capacity throughout the year. No new developments are reported from this field. The total amount of bauxite mined in Tennessee in 1912 was 8806 long tons valued at $35.224.

[1] For analyses of these ores see the following:
Veatch, Otto, The bauxite deposits of Wilkinson County, Georgia, *Bull. Geolog. Surv. Ga.*, No. 18, pp. 430–447 (1909).
Min. Res. U. S., I, 929 (1909).
MINERAL INDUSTRY, XXI, 89, (1912).

Foreign Countries

France.—The principal French deposits of bauxite are located in southeastern France and extend from Toulon in a westward direction toward the foot of the Pyrenees. The ore was first discovered at Les Baux northwest of Marseille whence the name of the mineral, bauxite. Two varieties of ore are mined, white ore containing much silica and little iron and red ore containing a high percentage of iron and little silica. As a rule the French bauxite runs lower in silica than the American ore but higher in iron.

The bauxite from France goes chiefly to England, the United States and Germany. France exported bauxite for the manufacture of aluminium amounting to 143,843 tons in 1912 and 154,218 tons in 1911. The amount of bauxite exported to the United States as declared at Marseilles was 28,987 tons in 1912. From Toulon the exports to the United States were 30,136 tons in 1912. The total value of the exportations of bauxite to the United States was $49,015 in 1912. Figures for 1913 are not yet available.

Germany.—Very little bauxite is produced in Germany. The importations chiefly from France amounted in 1913 to 38,450 tons as compared with 36,350 tons in 1912.

Italy.—There is but one producing mine in Italy the description of which is given in Mineral Industry, Vol. XX, p. 97. The amount produced in 1911 was 5690 tons valued at 63,728 lires.

United Kingdom.—The bauxite mined in the United Kingdom comes from four mines at Ulster, County of Antrim, in Ireland. The deposits occur in seams lying between sheets of tertiary basalt. The production in 1912 amounted to 5882 tons. In 1913 the amount mined was 6153 tons.

Uses of Bauxite

The chief uses of bauxite are for the production of the metal aluminium, and for the manufacture of aluminium salts, bauxite bricks for furnace linings, alundum for use as an abrasive and in the refractory industries and calcium aluminate to give a quick set to plaster compositions.

Metallic Aluminium.—By far the most important use of bauxite is for the production of the metal aluminium, the consumption of which is growing at a remarkable rate. A large part of the output of Arkansas and that also of France is used in the production of aluminium. This subject is taken up in detail in the chapter on Aluminium.

Bauxite Brick.—The cost of bauxite brick is high as compared with silica or fire-clay brick but their lasting quality is greater and their use is being extended where a brick high in alumina and low in silica is required, as in the lining of rotary cement kilns, lead-refining furnaces, and basic open-hearth steel furnaces. (For descriptions of the process of preparing bauxite brick for these uses see MINERAL INDUSTRY, XXI, pp. 93, 94 (1912), and Min. Res. U. S., I, 954, 955 (1912).

Aluminium Salts.—Another important application of bauxite is for the manufacture of aluminium salts such as alum and aluminium sulphate, for which use the purer ores only are suitable. Owing to its freedom from iron oxide most of the Alabama-Georgia product is sold for this purpose.

The following table[1] gives the domestic production, the imports, and the value of aluminum salts from 1909 to 1913, inclusive, in short tons.

Years.	Production.						Imports. (a)	
	Alum.			Aluminum sulphate.			Quantity.	Value.
	Quantity.	Value.	Per ton.	Quantity.	Value.	Per ton.		
1909.....	9,237	$295,682	$32.01	115,366	$2,214,122	$19.19	1,459	$29,061
1910.....	9,090	300,763	33.09	126,792	2,447,552	19.30	2,127	53,671
1911.....	10,468	329,686	31.49	134,077	2,743,336	20.46	2,283	56,833
1912.....	9,246	293,995	31.80	150,427	2,909,495	19.34	3,342	84,606
1913.....	9,605	312,822	32.57	157,749	2,977,708	18.88	2,702	66,549

(a) Includes alumina, aluminum hydrade, or refined bauxite, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground.

Alundum.—An important use for bauxite is for the manufacture of the artificial abrasive alundum, a description of which will be found under the heading "ABRASIVES."

Cement and Plaster.—The application of bauxite in the manufacture of calcium aluminate to give a quick set to cement compositions is a recent extension of the uses of bauxite. The inventions, which are covered by a series of patents, relate especially to the regulation of set of cement compositions by the use of hydraulic calcium aluminate prepared from bauxite. See also under "GYPSUM."

OTHER SOURCES OF ALUMINIUM

ALUNITE.—Alunite is a mineral with a theoretical content of 11.4 per cent. potash (K_2O) and 37 per cent. alumina. While the mineral is

[1] U. S. Geological Survey.

seldom found pure in nature, its deposits are of importance as a possible source of both potash and alumina, and interest therefore attaches to several of the recent discoveries of this mineral by geologists of the U. S. Geological Survey.

Arizona.—A recent investigation of the Nogales region, in southern Arizona, by F. C. Schrader, of the Survey, revealed a deposit of alunite. Analyses of rock samples collected from the Evening Star copper prospect by Mr. Schrader showed large percentages of alumina and potash, and while the discovery of the alunite was only incidental to the investigation of the copper deposits, it has served to suggest that other alunite deposits may be found in this formation, which occupies an area of many square miles. Mr. Schrader states that the porphyry belt in which the alunite was found "would commend itself for prospecting in case a practical process is developed for the reduction of alunite to soluble potash salts, and in the light of the fact that a study of the alunite deposits near Marysvale, Utah, and in other parts of the western states that the porphyry belt in which the alunite the mineral alunite may become at some future time an important source of alumina."

Nevada.—Another deposit of alunite discovered by Mr. Schrader is at Bovard, Nev., where, he says, the rocks show as high as 10 and 11 per cent. of potash. The actual extent of the deposits of the Bovard district is not known, as the character of the rock was not recognized by Mr. Schrader on the ground, so that no prediction of the possible value is justified.

Utah.—The Utah state land board has surrendered its rights to a section of the alunite land at Marysvale, Piute county, and made possible steps to develop the industry. The land can now go to patent. Howard Chappell, formerly a director in the General Chemical company, of New York, and C. H. MacDowell, of Chicago, president of the Armour Fertilizer company, are planning to develop an immense industry here based on a process invented by Mr. Chappell, whereby they expect to recover aluminium and potash.

No aluminium has been produced commercially as yet from alunite, but it is the belief of many chemists that a suitable process will be found. Much money will have to be spent in further experimenting and the examination of the deposits, to determine the quantity of alunite available, whether its purity persists with depth, in the erection of suitable plant, and the general expenses incidental to the starting of a new industry.

South Australia.—Recently it was reported[1] that a rich deposit of alunite had been discovered at Carrickalinga Head, on the southeastern shore of Spencer's Gulf, South Australia. The Government Geologist

[1] *Austr. Min. Std.*, Dec. 18, 1913.

has just issued an exhaustive report dealing with the occurrence, in which he states that the alunite exposed is of high quality. The alunite is of exceptional purity, and where unaltered by weathering is snow white. It occurs in compact micro-crystalline aggregates, and breaks with a conchoidal fracture. A freshly broken surface has the appearance of unglazed porcelain. The mineral is brittle, and massive specimens are easily broken into fragments. A noticeable feature of the weathering is the fact that it proceeds inward from the edges and corners of the veins in such a manner that spheroidal blocks of ore are found immediately below the surface. The rounding is due to gradual weathering *in situ*, not to attrition. A few specimens taken from various exposures were bulked to form an aggregate sample of the picked stuff, and on being analyzed by the departmental analyst were found to contain: Sulphuric anhydride, 35.81; alumina, 34.90; ferric oxide, 0.64; lime, minute trace; magnesia, minute trace; potash, 10.36; soda, 1.12; water at 100° C., 2.25; water above 100° C., 13.74; silica, 0.66; phosphoric anhydride, 0.28; chlorine, 0.55—100.31; less oxygen equivalent to chlorine, 0.12—100.19. The alunite occurs in complex vein systems, which are only partly exposed in the excavations that have been made. The component veins of the vein systems vary in thickness from an inch or less to an observed maximum of 3 ft.

HALLOYSITE[1]

An interesting deposit of what to all appearances is the mineral halloysite has recently been developed in the northeast corner of Chatooga county, Georgia. The mining operation thus far is confined to a small area near the southern end of Armuchee valley, along the east base of Taylor ridge, and can be best reached by driving from Summerville, a station on the Central of Georgia railroad, via Gore, a small settlement 7 miles east, thence north along the valley a distance of 4 miles.

The halloysite which is in the form of a true-bedded deposit lies directly between the Fort Payne chert and the Floyd shale, and where it has been opened shows a variable thickness of from 4 to 10 ft. with an average of perhaps 7 ft.

The material varies in color from a deep buff, through pink, orange and reddish hues, to a pale green and almost snow white, all being mottled with infiltrations of black oxides of manganese. In some parts of the bed there are pockets of soft, flaky white, clay-like material, while in other places there are seamlets or small lenses of pink and orange colored gelatinous matter. The bulk of the material, however, has a decidedly waxy appearance, is white or buff colored, breaks with a concoidal

[1] A new occurrence and use of Halloysite, Joel H. Watkins, *Min. Eng. World*, Apr. 12, 1913.

racture, has a hardness of from 2 to 3 and is slightly translucent. In he brecciated portions of the bed, the angular fragments are all buff colored and the cementing material is white, thus indicating that the buff is the oldest portion of the bed.

The origin of this occurrence of halloysite has not yet been determined, but it is probably a secondary product derived from what was originally a bed of white, highly-aluminous clay, which may have been similar in character to the so-called sedimentary kaolins of the Cretaceous beds in South Carolina and Georgia.

Mining thus far has not been conducted in a systematic manner. Four entries have been driven into the seam within a distance of 150 ft., the deepest of which at the time of the writer's visit was not more than 125 ft. into the mountain. On account of the softness and texture of the material it can be mined almost exactly as if it was coal, and the slight dip of the beds makes possible a self-draining mine. The roof of the mine is of compact cherty limestone, and very little timbering is required. The output is at present being hauled in wagons a distance of 4 miles to Gore, the terminus of the Rome & Northern railroad, which is an iron and timber industrial road.

The owners and operators are the stockholders of the North American Chemical Co., which was organized for the purpose of manufacturing aluminium sulphate and other products from the mineral. The process for the manufacture of alum from halloysite, consists in treating the raw material in the presence of moisture with warm dilute sulphuric acid, thus dissolving the aluminium in the form of aluminium sulphate. Experiments have proven that the aluminium cannot be dissolved economically if the halloysite has been even partially calcined.

Two analyses made by D. J. Demorest of the School of Mines, Ohio State University, from carefully taken samples of this bed are as follows:

	White sample.	Buff sample.
Water	19.95	20.40
Silica	42.20	37.10
Alumina	37.30	41.00
Iron oxide	Trace	Trace
Manganese oxide	0.11	0.38
Cobalt oxide	0.12	1.06
Titanium	Trace	Trace
Lime	Trace	Trace

As the market for commercial alum is almost entirely in the north, a plant having a capacity of producing about 50 tons of alum per day has recently been installed at Urbana, O. It is claimed by this patented process that for each ton of ore it requires 2700 lb. of sulphuric acid to dissolve the aluminium content, which leaves about 800 lb. of finely divided silica as a residue. The marketable aluminium sulphate thus produced contains from 45 to 51 per cent. of water, therefore it would

seem that from each ton of halloysite about 2 1/2 tons of commercial alum is manufactured. No mechanical separation is required, and the run of mine tonnage is simply ground to a uniformly fine consistency before being treated with warm dilute sulphuric acid. The finished product is almost entirely free from iron and other impurities and is consequently of excellent quality.

The cost of producing a ton of alum at the Urbana plant is as follows:

Cost per ton of ore on cars near mine	$ 2.00
Freight per ton from mine to Urbana	3.60
Sulphuric acid for 2 1/2 tons alum	13.50
Labor for 2 1/2 tons alum	4.00
Management, etc	1.00
Plant depreciations, renewals, etc	.50
Total cost, 2 1/2 tons alum	$24.60
Cost per ton at Urbana, O	9.84

ALUM

Turkey.[1]—The small city of some 13,000 inhabitants in the eastern part of the Turkish Vilayet (or Province) of Sivas that bears the official name of Kara Hissar Sharki, or Eastern Kara Hissar, is generally known on maps and in common conversation as "Shabin Kara Hissar" (Shab meaning alum). It seems certain that the alum workings within a short distance from the town have been in operation for at least 300 years, and have given the designation of "Shabin" to the town, just as Afion (opium) Kara Hissar in western Anatolia, and a small town called Develi (place of camels) Kara Hissar near Cesarea, have acquired their names through some special feature in the regions in which they are situated. The term "Kara Hissar" is applied to a peculiar outcropping of blackish rock in the form of a tall peak or mountain that exists near each of these towns. The hill against the sloping of which Shabin Kara Hissar is built is surrounded by a well-preserved masonry tower and fortress that must have been very strong in the days of medieval warfare.

There is a plentiful supply of the rock or raw material, as the operations so far have been primitive, and only the face of the hillside has been dug out and reduced. The alum-bearing rock is brightly colored, usually with a pinkish or red tinge, and the waste from the Goynyk workings flows down to a small stream along the roadside, to those waters it gives a pinkish white and opaque color, incidentally killing all the brook trout that happen to venture into the stained water from the higher part of the stream.

The operations are conducted by Greeks from the near-by villages. Wood for fuel, taken from the surrounding mountains until they were

[1] *Daily Cons. and Tr. Rep.*

denuded, is now brought from relatively long distances. The process of alum extraction is briefly as follows: The rock or ore is first roasted and then broken into small pieces, which are very light because the chemical elements have been burned out. Fifty horseloads of 100 okes (282 lb.) each of wood are required to burn 10 tons of stone in the furnace. The broken rock is then placed in open pits and allowed to be exposed to the rain and weather for a whole winter, during which time it becomes something like slacked lime, crumbling easily and finely granulated. In this state it is boiled with water in a large cauldron, the stone and waste matter being gradually taken out as it is stirred. Having been sufficiently boiled, the liquid, now almost clear, is placed in cooling tanks made of masonry. In the course of a few days the alum crystallizes around the sides of these tanks to a thickness varying from 6 to 9 in. It is then ready to be broken into smaller pieces and sent to market. The small portion of alum that sinks to the bottom of the tanks is boiled a second time and yields a superior quality.

From a reliable source it is learned that the annual production of alum in this region is 2000 to 3000 tons. The alum extracted at Goynyk is said to be the strongest and most concentrated. Other workings are at Gotadza and Geliese.

Alum is consumed locally, and large quantities are shipped to Harput, Diarbekr, and regions farther inland. There seems to be no exportation to foreign countries. The principal uses of alum are connected with the dyeing of cloth and yarn, the preparation of leather, and medicinal purposes. Not the least important use is as a charm, a triangular piece being placed in a case made of silver, blue beads, etc., and worn about the neck of both human beings and animals. The price of alum at the mine is about 5 to 7 piasters per batman (about 17 lb.), or 1 1/4 to 1 3/4 cents per pound, while in the market of Kara Hissar it retails for about 2 1/4 cents per pound.

The future of the industry depends largely upon improved methods of extraction, such as the use of coal for fuel, and upon a wider and more profitable market. The first improvement can be easily secured, as at Goynyk there are plentiful untouched supplies of coal within a few hundred yards of the workings. The latter is dependent upon better transportation facilities.

Australia.—A discovery has been made on private property near Normanville, in the Yankalilla district of South Australia, of what is declared to be a valuable formation of clay, which is identified as alum stone. A sample of the deposit was forwarded to the Adelaide School of Mines for analysis. It is said that the clay is found in only one other part of the Commonwealth.

BIBLIOGRAPHY

HART, EDW.—Potash, Silica and Alumina from Feldspar. *Jour. Ind. Eng. Chem.*, **4**, 827–8.

KISPATIC, M.—Bauxite from the Croatian Karst Region and its Origin. *Neues. Jahrb. Min. Geol.*, **34** (*Beil. Bd.*), 513–52.

MARTIN, E.—Analysis of Bauxites. *Mon. Sci.* [5] **3**, 232–6.

SAUNDERS, L. E.—Uses of Alumina as an Abrasive and Refractory. *Met. Chem. Eng.*, **11**, 143.

SCHWAHN, H. F. D.—Making Aluminium Sulphate from Bauxite. U. S. Patent 1077, **483**, Nov. 4, 1913.

STONE, S. R.—Bauxite Brick for Kiln or Furnace Lining. *Min. Eng. World.* **37**, 341.

TONE F. J., and ALLEN, T. B.—Making crystalline alumina. U. S. Patent 1044296. Nov. 12, 1912.

VERES, M. H.—Portuguese Keramohalite—Natural Hydrated Aluminium Sulphate. *Rev. Chim. pura app.*, **8**, 562–5.

WATKINS, J. H.—Bauxite Near Elizabeth, Tenn., *Eng. Min. Jour.*, Mar. 22, 1913.

BISMUTH

By C. H. MaGuire

Bismuth continues to be one of the metals that is imported in large quantities. This is due to the limited domestic production. The outlook for increased production, however, is very bright. The imports in recent years have been falling off steadily. No large deposits of bismuth ore are known in the United States, but several rich deposits are found in Colorado. The ore is not mined for its bismuth content. The principal producers are the U. S. Smelting, Refining and Mining Company, Grasselli, Ind., and the American Smelting and Refining Company, Omaha, Neb. The bismuth is obtained as a by-product in the electrolytic refining of lead. Bismuth from this source amounted to about 185,000 lb. during the year 1913

The following table gives the imports since 1904:

Year.	Quantity, lb.	Value.
1904	161,240	$295,200
1905	153,668	305,471
1906	243,926	378,652
1907	215,647	262,775
1908	225,833	313,919
1909	176,729	274,662
1910	200,221	316,838
1911	178,298	321,360
1912	166,980	305,282
1913 (a)	151,030	257,176

(a) Dept. of Commerce.

In spite of the facility with which it is handled metallurgically bismuth commands a high price. This is due to its scarcity and the control of the market by a foreign syndicate. Bismuth can probably be produced at a cost of about 25 cents per pound, but sells at from $1.75 to $2.00 per pound.

The world depends largely upon South America for the supply of bismuth. Bolivia is the chief producer. The main output comes from the Tazna district, though rich bismuth ores occur generally in the district centering about La Paz and Chorolque. Recently veins have been opened in the Department of Potosi. The following table gives the output of Bolivia for recent years:[1]

Year.	Quantity, Metric tons.
1909	139
1910	134
1911	242
1912	263
1913	275

[1] Bismuth: Its Properties and Sources of Supply, T. H. Osborne, *Chem. Eng.*, XVII, 4.

In Peru are many localities in which bismuth ores are found, but at present only one deposit is being worked. During the year 1913, about 200 tons of bismuth concentrate were shipped. The ores average 1 to 2 per cent. bismuth.

Several deposits of bismuth are known in Brazil but have not yet been developed. It is not known whether these deposits can be worked profitably. Near Potrero Grande, Chile, a mineral, called chilenite and consisting of an alloy of bismuth and silver, is found.

A few years ago mines were opened near Herberton, Queensland for wolfram which at that time was commanding a high price. These deposits, which contain from 7 to 8 per cent. bismuth, were abandoned, but recently have been reopened for the bismuth content. The veins, made up of topaz, wolfram and bismuth carbonate, vary in thickness from 8 to 13 in. Near Maldon, Victoria, occurs a molybdenite containing 5 per cent. bismuth, also a bismuth pipe with 26 per cent. The occurrence of native bismuth associated with tin veins is reported from Madagascar.[1] The production of bismuth minerals in Australia for recent years is shown in the following table:

PRODUCTION OF BISMUTH MINERALS IN AUSTRALIA
(Tons of 2240 lb.)

Year.	Queensland.		New South Wales.	
	Tons.	Value.	Tons.	Value.
1903	11.0	£2,523	21.7	£9,537
1904	20.9	3,581	40.3	12,329
1905	15.3	5,368	55.8	20,763
1906	6.5	1,882	25.9	5,700
1907	6.3	1,806	16.3	5,268
1908	22.7	10,595	8.7	2,017
1909	10.3	2,271	8.6	1,624
1910	21.0	9,708	6.4	2,004
1911	9.8	5,525	7.9	1,800
1912	5.0	2,835	5.8	1,210
1913	.....	.....	.....	.....

The report of the Secretary of Mines of Tasmania shows a production in 1913 of 5.08 tons of bismuth, valued at £1627.

Europe.—Bismuth is obtained from lead and silver ores in Saxony, in Bohemia and South Germany. Refined bismuth from Saxony contains 99.98 per cent. bismuth and small quantities of lead and copper.

Canada.—Bismuth occurs on the Stewart River, the Montreal River, at New Ross, Lunenberg County, near Kewagama Lake, Quebec, and near Lyndock and Clarendon, Ontario.

Bismuth has been produced in Spain, Japan, Norway and Rhodesia, but the production in recent years has fallen off considerably.

[1] Bismuth-bearing Minerals from the Pegmatites of Madagascar, A. Lacroix; *Bull. Soc. franc. min.* XXXV, 92–5.

Metallurgy.—Bismuth is extracted from its ores by treatment with hydrochloric acid and subsequent precipitation of the bismuth with either water or iron. The precipitate is then reduced by heating with carbon. In Germany the ore is roasted which results in a uranium-bearing slag, a cobalt speiss, and a crude bismuth matte from which the bismuth is obtained by crystallization. Lacey describes the refining of silver-bismuth alloys by electrolysis.[1]

Properties and Uses.—Bismuth is a silver white, lustrous metal of a specific gravity of 9.823. Its melting point is 268.3° C. In appearance bismuth resembles antimony but has a foliated structure. Upon solidifying, bismuth expands about 2.3 per cent., a property which makes the metal valuable in the production of stereotype plates. It is not affected by dry air, but in moist air becomes coated with a reddish powder. Heated in the atmosphere the metal burns, forming the trioxide, Bi_2O_3. Hot sulphuric acid converts it into a basic sulphate. Bismuth alloys readily with other metals, and imparts to them the properties of hardness and ready fusibility. It is used in the production of fusible alloys, as an amalgam, with or without tin and lead, for silvering mirrors, and in the manufacture of electric fuses.

Bibliography

Anon.—Metallurgy, Properties and Value of Bismuth Ores. *Bull. Imp.Inst.*, X, 628–41. *Min. Eng. World*, XXXVIII, 343–4.

Anon.—Occurrence, Distribution and Utilization of Bismuth Ores. *Bull. Imp. Inst.*, Dec., 1912. Abst., *Min. Eng. World*, Feb. 15, 1913.

Bekier, E.—The Spontaneous Crystallization of Bismuth and Antimony. *Z. anorg. Chem.*, **78**, 178–82.

Coblentz, W. W.—Summary of Tests made on Bismuth Thermopiles. *J. Wash. Acad.*, **3**, 357–60.

Kurnakov, N. S., Zhemchuzhnui and Tararin, V.—Combinations of Varying Composition in the Alloy of Thallium and Bismuth. *J. Russ. Phys. Chem. Soc.*, **45**, 300–29.

Northrup, E. F. and Suydan, V. A.—Resistivity of a Few Metals through a Wide Range of Temperature. *Jour. Frankl. Inst.*, Feb., 1913.

Lazarevic, M. and Kittl, E,—The Bismuth Veins of Aljin Dol and Jasikova, Servia. *Z. prakt. Geol.*, **20**, 280–7.

Parravano, N.—The System: Bismuth-Selenium. *Gazz. chim. ital.*, **43**, I., 201–9.

Smith, A. W.—Hall Effect in Bismuth with High Frequency Current. *Phys. Rev.*, **35**, 81–5.

Schottky, H. and Tevin, M.—Calorimetric Investigation of the Systems Bismuth-Cadmium and Iron-Carbon. *Ferrum*, **10**, 103–207.

[1] Electrolytic Refining of Silver-Bismuth Alloys, W. N. Lacey, *Trans. Am. Electrochem Soc.*, XXII, 304; *Met. Chem. Eng.*, X, 747.

BORAX

The price for borax in 1913 ranged very steady at 3 3/4 @ 4 cents per pound for carloads. The demand, particularly from the enameling industries, was good. The mines in San Bernardino and Ventura counties in California continued to supply practically all the borate minerals required for the entire country, as can be seen by the following table of imports:

UNITED STATES IMPORTS OF BORAX, ETC.
(Fiscal Years ending June 30.)

Year.	Borax.		Borate of Lime, Etc.		Boracic Acid.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1908.....	1,964,792	$67,851	2,640	$132	414,046	$19,773
1909.....	341,058	13,173	1,646	167	230,968	7,641
1910.....	9,058	1,479	19,201	1,855	416,842	13,610
1911.....	7,319	790	13,095	2,277	343,094	12,733
1912.....	6,409	604	22,784	3,856	276,496	10,540
1913.....	11,768	882	16,267	2,038	362,400	13,897

Deposits of colemanite were discovered in Ventura County, Cal., in 1898. This colemanite, although classed, among the few important deposits of this kind of ore in the country, has suffered the disadvantage of being a long distance from the main routes of transportation. As in the case of many other western industries, however, it is expected that the opening of the Panama Canal will greatly stimulate production. An examination of the borate deposits of Ventura County was recently made by Hoyt S. Gale, of the United States Geological Survey,[1] and while the investigation was not sufficiently detailed to permit an expression of opinion as to the magnitude of the undeveloped deposits, it is believed that they are very considerable.

The growth of the borax industry has depended upon two things, the increase in the business of the manufacturers using borax in their processes and the education of the consuming public to the merits of borax as a household commodity.

It is generally recognized that boric acid in considerable quantities is an original constituent in the waters and gases given off with volcanic emanations. In fact, the Tuscan fumaroles, in Italy, have been an important commercial source of boric acid for a long time, and in the

[1] Advance Chapter O, *Bull.* 540, U. S. Geol. Surv., Washington, D. C

past, possibly even to the present time, almost all the boric acid brought into the European market has been derived from this source. There is abundant evidence of the presence of boric acid in volcanic emanations in many parts of the world. On the other hand, boron is so rare a constituent of rock-forming minerals that it forms an almost inappreciably small percentage of the earth's rock mass as a whole.

A short study of the borate deposits in Ventura County, Cal., supplemented by more cursory examinations of similar deposits in the vicinity of Death Valley, has been made by Gale, and a new theory of the origin of the deposits of colemanite, or borate of lime, in these regions has been advanced.[1] While this theory has not yet been entirely proved, there is much in its favor and it affords suggestions and a working basis for further observation.

The supposition of a desiccated saline lake to explain the origin of the colemanite has little to support it beyond rather general assumptions. The character of the deposits themselves indicates rather a vein type of formation. Other salines which would naturally be expected in desiccation deposits resulting from natural saline solutions are not found in association with the colemanite. Those who have supported the desiccation theory have offered no explanation of the cause which might produce colemanite in such massive deposits as a product of water evaporation, while, on the contrary, its formation from limestone in veins by replacement of carbonic acid with boric acid is a natural hypothesis that deserves further investigation. The relations of the deposits to basalt lava flows indicate the probable origin of the boric acid at the time of the extrusion of these lavas, although it may be assumed that this acid continued to find its way into solution of the circulating ground waters long after the period of the extrusions.

PRODUCTION OF BORATE ORES IN CALIFORNIA. (a)
(In tons of 2000 lb.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1901.....	7,221	$982,380	1905...	46,334	$1,019,158	1909...	16,628	$1,163,960
1902.....	(b)17,202	2,234,994	1906...	58,173	1,182,410	1910(d)	42,357	1,201,842
1903.....	34,430	(c)661,400	1907...	53,412	1,200,913	1911(d)	53,330	1,569,151
1904.....	45,647	(c)698,810	1908...	22,200	1,117,000	1912(d)	42,315	1,127,813
						1913(e)	58,000	$1,560,000

(a) Reported by the California State Mining Bureau. (b) Mostly refined borax, whence the apparent discrepancy in value. Output of the other years is given as crude material. (c) Spot value. (d) U. S. Geol. Survey, crude. (e) Estimated.

Asia Minor.—A rich deposit of boracite occurs near Panderma (Sea of Marmora), at Balik Kesir, and is worked by the Borax Con-

[1] Professional Paper 85-A, U. S. Geol. Surv., Washington, D. C.

solidated, Ltd. The production averages 14,000 tons per annum, containing the equivalent of 47.60 per cent. boracic acid.

Chile.—The export tax contemplated by the Chilean government on the calcined borax may cause a decline of the operations of the Borax Consolidated, Ltd. at Ascotan, near Antofagasta. Chile contributes about 75 per cent. of the world's production.

Peru.—The deposits of borax near Arequipa (in the department of that name), which are owned by the Borax Consolidated, Ltd., will be actively exploited under the concession recently granted by the Government. The concession was made public by the Minister of Finance under date of June 3, and is as follows:

1. To authorize the Borax Consolidated, Limited, to construct, at its own expense, under the existing regulations, a railway, or if it should prove too expensive, an aerial rail, from the borax and salt mines in the province of Moquegua, department of Arequipa, to the city of Arequipa.

2. The aforesaid Company agree to install in the city of Arequipa, or in the neighborhood, or near the mines, furnaces of sufficient capacity to calcine annually at least 40,000 metric tons of borax and lime.

3. When the demand in the market requires a greater amount than 45,000 tons yearly the Borax Consolidated, Limited, will increase in proportion the exportation of borax.

4. The aforesaid Company will transport annually from the borax and salt mines to Arequipa 1200 tons of salt and will bring back on the return journey all the necessary food for the employees and workmen of the *Compañia Salinera del Perú.* The price for the carriage to be, by the railway, 40 centavos for a Spanish quintal, of 46 kg., and by the aerial rail, 20 centavos for a Spanish quintal, of 46 kg. The Borax Consolidated, Limited, will not be obliged to transport this cargo by the aerial rail on days when it is raining.

5. The petitioning Company is under the obligation of establishing a telephone wire between Arequipa and the salt mines and permitting the political and military authorities to use it.

6. Only Peruvian workmen will be employed in the works, whether in the salt fields or in Arequipa or at the intermediate stations.

7. The Borax Consolidated, Limited, will be responsible for the sum of £200,000 to be spent on the works for which this concession treats.

8. Only 10 per cent. above cost price will be charged in the shops, which the Company will establish, to their employees for food and other necessities.

9. The Supreme Government agrees to ask the Legislative Chambers the following:

(a) A declaration that the Congress will not levy duty on the exporta-

tion of borax from the port of Mellendo for 18 years, commencing from the date that the Borax Consolidated, Limited, begins its exportation at the rate of 20,000 metric tons of calcined borax and lime.

(b) That all rails, wire, engines, carriages, motors, iron and steel posts, and all other necessary materials imported for the installation of the railway or aerial rail will be free of duty.

(c) The declaration of the Legislature that the municipalities of the neighborhood will put no tax on borax for the aforesaid 18 years.

10. To authorize the Minister of Finance, in order that, before acceptation by the solicitor, he sign the deed, which with all the preceding will be submitted to the Legislative Chambers for their consideration.

SOME OF THE PRINCIPAL SUPPLIES OF BORAX MATERIALS.
(In metric tons.)

Year.	Chile. (a)	Germany. (b)	Italy.			United States. (c)	Total. (d)
			Borax Refined.	Boric Acid.			
				Crude.	Refined.		
1899	14,951	183	709	2,674	129	18,466	37,112
1900	13,177	232	858	2,491	283	23,437	40,478
1901	11,457	184	544	2,558	347	6,550	21,640
1902	14,327	196	.....	2,763	.....	15,512	32,798
1903	16,879	159	.....	2,583	.....	31,232	50,853
1904	16,733	135	569	2,624	314	41,407	61,782
1905	19,612	183	(e)1,007	2,700	(e)749	42,036	64,531
1906	28,996	161	1,062	2,561	562	52,774	86,116
1907	28,374	114	881	2,305	466	47,945	80,584
1908	35,039	128	(e)1,024	2,520	(e)429	22,680	57,827
1909	32,218	149	(e)1,110	2,431	(e)578	37,589	51,569
1910	35,192	167	(e) 912	2,502	(e)695	38,426	?
1911	45,558	160	(e) 738	2,648	(e)444	48,381	.....
1912	43,356	.....	(e) 813	2,309	(e)760	38,388	.....
1913	.....	.....	.....	.....	.....	52,600	.....

(a) Prior to 1903, figures are for borate of lime exports. (b) Boracite. (c) Crude borax. (d) The total falls short of the world's supply, particularly because it fails to include the important production of Turkey. (e) Obtained by treating a part of the crude boric acid reported for the same year.

"Technical Applications of Boron"

Progress During the Year 1913

By E. Weintraub

Boron is a newcomer among the elements. It is only a few years ago that it has been isolated in the Lynn laboratory of the General Electric Co. and that the work on utilizing its unique qualities has been started. Considering the short interval of time elapsed and the fact that all the work was done by a small group of men in one place, the results are gratifying. Several applications of boron are already commercialized. Others have passed the severe tests of actual use and are ready to be commercialized; still others are just emerging from the laboratory.

Boron Flux for Copper Casting

The use of boron as a deoxidizer in copper casting has given a perfect solution of the problem of casting high conductivity copper. The process is based on the lack of affinity of boron for copper and on its great affinity for oxygen or oxygen-containing gases. The process is used in all the foundries of the General Electric Co. and by a number of other concerns both in the United States and abroad. Its use is rapidly spreading. From the amount of boron flux sold, seventy thousand (70,000) pounds of copper were cast 2 years ago and more than half a million pounds last year (1913). For a detailed description of the process, the reader may be referred to the following articles:

"Cast copper of high electrical conductivity." *Trans. Am. Electro. Chem. Soc.*, XVIII, 207 (1910).

"Progress of work on boronized copper." *Trans. Am. Inst. Metals*, 1912.

Boron Voltage Regulator

Boron has an exceptionally large negative temperature coefficient of resistance so that its resistance drops in the ratio of about two million to one between 0° C. and a good red heat. The volt-ampere curve of boron has, therefore, a peculiar shape of such a nature that if a certain maximum voltage is exceeded, *the voltage decreases with increase in current.* By adding to boron carbon or other elements in definite amounts the negative temperature coefficient of resistance can be tempered and the slope of the volt-ampere curve varied to suit conditions. In particular, the curve can be given such a shape that the voltage remains practically constant while the current varies between certain limits.

Different forms of the regulator have been developed for different applications. They all consist of a thin boro-carbon filament sealed in a bulb containing a hydrogen atmosphere. The filament form and the hydrogen atmosphere are used to facilitate the heat energy exchanges and to make the action of the regulator more rapid. The different types of regulator so far developed are:

(1) *Suburban Carlight Regulator.*—Used on suburban cars where a variable voltage derived from the trolley is supplying the lamps. A boron regulator with a level volt-ampere curve is placed across the lamps and keeps the voltage constant while the excess of voltage is absorbed in resistance in series, a resistance which for highest efficiency takes the form of a tungsten ballast.

(2) *Automobile Light Regulator.*—In this case the regulator is to deliver constant voltage at variable speed. A regulator with a sloping

volt-ampere curve is placed in a differential field of the generator and so adjusted that any tendency of the voltage to increase due to increase in speed is counterbalanced by the disproportionate increase in the field strength.

(3) *Train Lighting Regulator.*—This is very similar to the automobile light regulator except for the quantitative relations.

These regulators have been on test in actual service for more than a year on car lines in Schenectady and Lynn, on automobiles, etc., etc., and have given perfect satisfaction. Their commercial exploitation is soon to begin.

Boron Cut-out

The existence of a maximum voltage in the volt-ampere curve below which the current flowing through boron is very small and above which the current increases and the voltage across the boron decreases disproportionately makes properly designed boron units the ideal protecting device for incandescent lamps, arc lamps and other devices on series circuits. These cut-outs are remarkable for their constancy and for the fact that they never need be replaced as they regain their properties on cooling.

Boron Jewel

Boron and boro-carbon belong to the hardest artificial materials and after persistent efforts it was found possible to produce them in a homogeneous, dense and tough form, in which form they show a remarkable performance when used as bearings in meters. Tests carried out during a number of years have proven their value and they are now being introduced into service.

For further information on the properties of boron and its uses, the reader may be referred to my lecture before the VIIIth International Congress of Applied Chemistry, New York City, September, 1912.

While the uses of boron pointed out above will form a basis of an important industry, they will consume but relatively small amounts of the element and this is fortunate from a certain point of view, for up to the present the cost of boron per pound is quite high.

Bibliography

Anon.—A New and very Soluble Borax. *Rev. sci. Giorn. farm. chim.*, **61**, 493.

Berger, C.—Borax in Metallurgy and Tanning. *Rev. gen. Chim.*, **16**, 133.

Bleininger, A. V., and Teetor, Paul.—A Thermal Study of Boric Acid-Silica Mixtures. *Trans. Am. Ceram. Soc.*, **14**, 210–17.

HEYDER, R.—Making Pure Boron Nitride. U. S. Patent 1077712, Nov. 4, 1913.

NASINI, R., and PORLEZZA.—The Presence of Large Amounts of Boric Acid in the Mineral Water from Salsomaggiore. *Atti accad. Lincei*, **21**, II, 379–83.

PURDY, R. C.—The Chemical Rôle of Boron in Glazes. *Trans. Am. Ceram. Soc.*, **14**, 731–9.

STAHLER, A., and ELBERT, J. J.—Fixation of Atmospheric Nitrogen by Means of Boron Compounds. *Ber.*, **46**, 2060–77.

STOCK, ALF., and MASSENEZ, C.—Boron Hydrides. *Ber.*, **45**, 3539–68.

TILLOTSON, E. W., JR.—Density of Some Borate and Silicate Glasses. *Jour. Ind. Eng. Chem.*, **4**, 820.

WEDEKIND, E.—Synthesis of Borides in the Electric Vacuum Furnace. *Ber.*, **46**, 1198–1207.

WEINTRAUB, E.—Boron: its Properties and Preparation. *Jour. Ind. Eng. Chem.*, **5**, 106.

WEINTRAUB, E.—Making Boron from Boron Chlorid and Hydrogen. U. S. Patent 1074672, Oct. 7, 1913.

WEINTRAUB, E.—Progress in Work on Boronized Copper. *Brass World*, **8**, 355–6.

WEINTRAUB, G., and RUSH, H.—Sintering Particles of Boron into a Homogeneous Mass. U. S. Patent 1071488, Aug. 26, 1913.

YALE, C. G. and GALE, H. S.—Production of Borax in 1912. *Min. Res. of U. S.*, 1912.

BROMINE AND IODINE

By C. H. MaGuire

The bromine industry in the United States is carried on principally in Michigan, Pennsylvania, Ohio and West Virginia. It is difficult to give exact figures of the output since the producers give no information in regard to the industry. The principal producers are the Dow Chemical Company in Michigan, and the John A. Beck Salt Company in Pennsylvania. The estimated production for the year 1913 was 794,500 lb., mostly in the form of bromides. The production of liquid bromine was the smallest for many years. No figures of the production are available.

The price of bromine remains about the same as that of 1912. The quantities used for metallurgical and medical purposes, and in the arts was the same as in the previous year. The only field in which the use of bromine is increasing is that of photography. This is due in large measure to the increasing motion picture business.

The following table shows the production of bromine in the United States for the period 1900 to 1913:

PRODUCTION OF BROMINE IN THE UNITED STATES.
(In pounds.)

Year.	Michigan. (a)	Ohio and Penn.	West Virginia.	Total. (a)	Metric Tons.	Value.	
						Total.	Per lb.
1900	210,400	196,774	114,270	521,444	237	$140,790	27
1901	217,995	227,062	106,986	552,043	250	154,572	28
1902	226,452	194,086	93,375	513,913	233	128,742	25
1903	320,000	180,000	97,000	597,000	271	170,145	28½
1904	646,249	147,807	85,256	879,312	399	215,431	24½
1905	579,434	223,000	97,000	899,434	408	139,492	15½
1906	955,000	203,000	71,000	1,229,000	553	184,350	15
1907	(b)	(b)	(b)	1,062,000	482	138,060	13
1908	(b)	(b)	(b)	1,149,000	521	103,410	9
1909	(b)	(b)	(b)	1,100,000	500	110,000	10
1910	641,300	155,000	54,000	850,300	386	110,539	13
1911 (c)	648,000	164,000	89,000	901,000	.....	180,000	20
1912	840,000	177,000	68,000	1,085,000	435	270,000	25
1913	(d)626,500	(d)123,500	(d)44,500	(d)794,500	.....	.....	.....

(a) Includes the bromine equivalent of the bromides produced directly. (b) Not reported separately. (c) From *Eng. and Min. Journ.* (d) Bromides.

Germany and England both export bromine. The supply of bromine in Germany so far exceeds the demand that the Bromine Convention has offered a prize to the discoverer of a process or compound which will lead to a greater consumption of bromine.

Iodine

No iodine is produced in the United States, although a possible source exists in the sea-weeds along the coast. The sea-weeds of California which are treated commercially for potash do not promise a large yield of iodine.

The imports of iodine are given in the following table:

Year.	Crude.		Resublimed.	
	Pounds.	Value.	Pounds.	Value.
1909	12,910	$25,705	51	$110
1910	771,083	1,051,036	7	24
1911	423,353	841,559	55	181
1912	379,311	737,109	40	96
1913	351,256	739,734	40	96

The principal source of supply of iodine is the mother-liquor from the nitre industry of Chile. The production for 1913 amounted to about 436,971 kg. Of the quantity of iodine exported in 1912, 238,904 kg. went to Germany, 154,490 kg. to the United States, and 54,664 kg. to the United Kingdom. Germany is the largest consumer of iodine.

Iodine imported into the United States is used in the production of iodoform, hydroiodate, and potassium iodate. The imports of iodide and hydroiodate for the fiscal years ending June 30, are shown in the table:

	Pounds.	Value.
1909	251	$508
1910	142	275
1911	272	519
1912	238	451
1913	120	239

The sea-weeds of Siberia are very rich in iodine. In 1910 plans for the establishment of a factory for the production of iodine from this source at Olga Bay were made by a Russian firm. The project was dropped when the Russian interests were purchased by a German chemical company which wished to limit competition.

Crude iodine is produced by a number of small producers along the southern coast of Japan. The principal producer is located at Hayama, about 20 miles from Yokohoma. The customs returns for 1912 show that in that year 22,772 lb. of iodine valued at $44,977 were exported to Germany, Hongkong, Great Britain, and Belgium.

During the year 1913 a process for the production of iodine from sea-weed has been perfected by Cameron and Moore (U. S. Pat. 1051984). The partially evaporated extract from the ash is electrolyzed in a diaphragm cell. The anode liquor containing iodic acid is then reduced with sulphuric acid and iron, or ferrous sulphate, thus liberating the iodine.

Bibliography

DU PONT, F. I.—Production of Bromine or Bromides. U. S. Pat. 1064460.

GILL, H. W.—Recovery of Iodine from Residues. *Analyst*, **38**, 409, 1913.

SCOTT, A.—The Preparation of Pure Bromine. *Chem. Soc. Proc.*, **29**, 124, 1913.

CADMIUM

By C. H. MaGuire

Cadmium occurs associated with zinc, and is obtained as a by-product in the smelting of zinc ores. The metallurgical process employed abroad is fractional distillation of zinc ores. The first producer of cadmium in the United States was the Grasselli Chemical Co., who placed their product on the market in 1906. At present there are two producers—the American Smelting and Refining Co. and the Grasselli Chemical Co. During the year 1913 the total production of cadmium was about 26,250 lb. The Grasselli Co. obtains its cadmium from the cadmium-bearing blue powder; the American Smelting & Refining Co. gets its cadmium from the bag-house fume. The process used is not made public.

The imports of cadmium have steadily decreased since 1906 from a value of $10,522 to a value of $1,508 in 1913. The imports since 1908 are shown in the following table:

	Pounds.	Value.
1908	.....	$2,166
1909	.....	4,643
1910	3,083	1,657
1911	5,956	3,718
1912	6,396	4,603
1913	1,999	1,508

The world's supply of cadmium comes chiefly from Upper Silesia, Germany. According to Messrs. Speier, of Breslau the production for the first quarter of 1913 totaled 9515 kg. During the corresponding period in the year 1912 the production was 10,881 kg. Because of the many small producers the exact production cannot be accurately determined.

A process for the production of electrodes for use in electric acumulators in alkaline electrolyte has been patented. (Ger. Pat. 250385; Ger. Pat. 252707.) Sponge cadmium is precipitated from a cadmium chloride solution by the use of zinc, magnesium, or aluminium and is then formed in the desired shapes.

Cadmium finds its most extensive use in the manufacture of fusible alloys, such as Wood's metal. (See Bismuth.) It has been used to some extent for filling teeth. The sulphide is a valuable pigment.

CEMENT

By Robert W. Lesley

Figures of the United States Geological Survey upon the cement industry for 1913 again show a growth in the production of cement. When the figures for 1912 were made public it was the general expectation that the 1913 production would show little, if any, gain over that of the previous year. This was especially the case in view of the financial conditions prevalent in the country, and the cessation to a considerable extent of large railroad construction.

Controverting this fact, the quantity of Portland cement produced in 1913 was 92,097,131 bbl. as compared with 82,438,096 bbl. in 1912, an increase of 9,659,035 bbl. or 11.7 per cent.

This ratio of increase is considerably more than that for the comparative period of 1912 where the increase in production was 3,909,459 bbl. or about 4.98 per cent. The 1913 increase is attributed to a considerable extent to the development of the use of concrete on the farm and also to the largely increased use of concrete for roads and highways—a use of recent development and one showing an enormous growth.

The total production of all kinds of cement, including Portland, natural and puzzolan, produced in the United States in 1913 was 92,949,102 bbl. valued at $93,001,169 as compared with 83,351,191 bbl. valued at $67,461,513 in 1912. This represents an increase in quantity of 9,567,911 bbl. or 11.5 per cent., and in value, of 25,539,656, or 38.9 per cent.

In considering the table showing total production of cement in the United States in 1911, 1912 and 1913 by classes (Table I) it must be remembered that the weight of Portland cement per barrel is 380 lb. net, while puzzolan is sold on a basis of 330 lb. and natural cement on a basis of 265 lb.:

TABLE I.—TOTAL PRODUCTION OF CEMENT IN THE U. S. IN 1911, 1912 AND 1913, BY CLASSES.

Class.	1911.		1912.		1913.	
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.
Portland	78,528,637	$66,248,817	82,438,096	$67,016,928	92,097,131	$92,557,617
Natural	926,091	378,533	821,231	367,222	744,658	345,889
Puzzolan	93,230	77,786	91,864	77,363	107,313	97,663
Total	79,547,958	$66,705,136	83,351,191	$67,461,513	92,949,102	93,001,169

According to the diagram Fig. 1, which is furnished by the Geological Survey showing the comparative figures of Portland and natural cements in this country for the periods 1890 to 1912, the remarkable growth of Portland cement as compared with that of natural cement may be noted.

In this connection, the output of natural cement of the Rosendale-Cumberland-Louisville-Milwaukee type, which in 1899 reached its maxi-

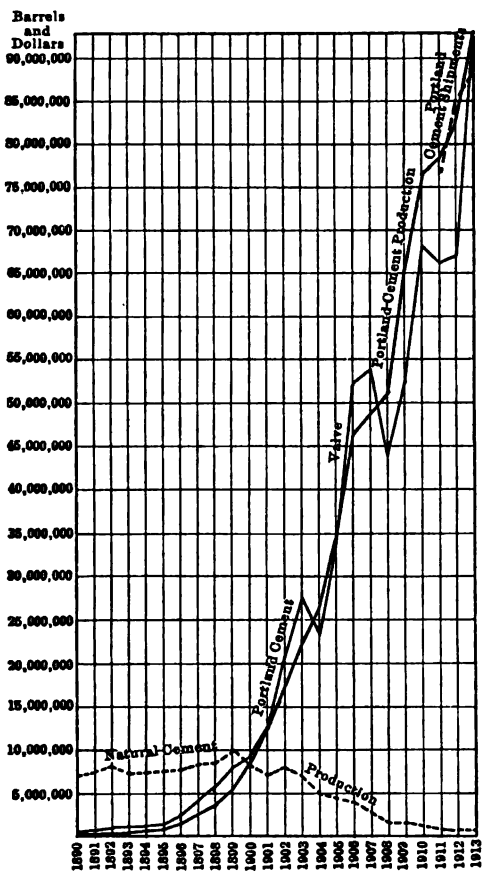

FIG. 1.—Production of Portland Cement

mum production with an output of 9,868,179 bbl., has been falling continuously since, until in 1913 it is a comparatively unimportant industry, though history shows in this country important work of all kinds, fortifications, foundations, bridges, etc., etc., constructed with

this well-known material for many years. On the other hand, the curve of Portland cement shows a continuous growth without a setback, from its earliest period of production in 1890 up to the completion of the past year.

The figures of the Geological Survey this year, it will be noted, are grouped primarily by commercial districts, these districts being places which have well-known distributing qualifications, and representing groups of works within certain areas influenced by practically similar trade conditions. This grouping, as shown in Table II, gives the following results:

TABLE II.—PRODUCTION AND SHIPMENTS OF PORTLAND CEMENT.

(Figures opposite P relate to production: those opposite S to shipments.)

District.		Active Plants.		Production and Shipments (Barrels).			Average Factory Price Per Barrel.		
		1912	1913	1912.	1913.	Percentage of Change, 1913.	1912.	1913.	Percentage of Change, 1913.
Lehigh district (New Jersey and eastern Pennsylvania)	P	22	22	24,762,083	27,139,601	+ 9.60	.....	.....	.....
	S.	25	22	26,013,891	26,659,537	+ 2.48	$0.674	$0.838	+24.33
New York	P	7	8	4,492,806	5,208,020	+15.92	.....	.....	.....
	S.	7	8	4,543,060	5,136,334	+13.05	.759	.934	+23.05
Ohio and western Pennsylvania	P	9	9	7,359,402	7,690,010	+ 4.49	.....	.....	.....
	S.	9	9	7,398,753	7,287,028	− 1.51	.757	1.000	+32.10
Michigan and northeastern Indiana	P	13	13	4,308,645	5,057,199	+ 1.73	.....	.....	.....
	S.	13	13	4,417,808	4,960,891	+ 1.22	.851	1.030	+21.03
Kentucky and southern Indiana	P	3	3	3,091,603	3,005,417	− 2.78	.....	.....	.....
	S.	3	3	3,134,841	2,861,624	− 8.71	.764	1.008	+31.93
Illinois and northwestern Indiana	P	6	6	10,659,357	12,423,799	+16.55	.....	.....	.....
	S.	6	6	10,677,479	11,576,938	+ 8.42	.744	1.002	+34.67
Maryland, Virginia, and West Virginia	P	4	4	2,325,885	2,668,338	+14.72	.....	.....	.....
	S.	5	4	2,536,546	2,529,629	− .27	.726	.865	+19.14
Tennessee, Alabama, and Georgia	P	5	5	2,411,372	3,082,623	+27.83	.....	.....	.....
	S.	6	5	2,544,663	2,958,829	+16.27	.746	.899	+20.50
Iowa and Missouri	P	8	8	7,583,933	8,427,012	+11.11	.....	.....	.....
	S.	8	8	7,804,901	7,941,620	+ 1.75	.832	1.074	+29.08
Great Plains States (Kansas, Oklahoma, and central Texas)	P	15	15	5,807,043	6,350,646	+ 9.36	.....	.....	.....
	S.	17	15	6,174,085	6,190,040	+ .26	.866	1.063	+22.75
Rocky Mountain States [a] (Colorado, Utah, Montana, and western Texas)	P	7	a8	2,299,252	a2,546,082	+10.73	.....	.....	.....
	S.	7	a8	2,234,602	a2,545,473	+13.91	1.165	a1.319	+13.21
Pacific coast States (California and Washington)	P	11	12	7,336,715	8,498,384	+15.83	.....	.....	.....
	S.	11	12	7,531,927	8,041,434	+ 6.76	1.358	1.461	+ 7.58
Total	P	110	113	82,438,096	92,097,131	+11.72	.....	.....	.....
	S.	117	113	85,012,556	88,689,377	+ 4.13	.813	1.005	+23.62

a Includes Arizona in 1913.

Comparing the two years, the old method of grouping by states, however, is not changed and upon this basis the production of Portland cement in 1912 and 1913 is as follows:

TABLE III.—PRODUCTION OF PORTLAND CEMENT.

State.	1912.		1913.		Percentage of Change, 1913.
	Producing Plants.	Quantity (Barrels).	Producing Plants.	Quantity (Barrels).	
Pennsylvania	23	26,441,338	23	28,701,845	+ 8.55
Indiana	5	9,924,124	5	10,872,574	+ 9.56
California	8	5,974,299	7	6,159,182	+ 3.09
New York	7	4,492,806	8	5,208,020	+15.92
Illinois	5	4,299,357	5	5,083,799	+18.25
Missouri	5	4,355,741	5	4,803,338	+10.28
New Jersey	3	4,246,803	3	4,460,027	+ 5.02
Michigan	11	3,494,621	11	4,186,236	+19.79
Iowa	3	3,228,192	3	3,623,674	+12.25
Kansas	10	3,225,040	10	3,374,836	+ 4.64
Washington	3	1,362,416	5	2,339,202	+71.70
Texas	4	1,807,769	4	2,117,142	+17.11
Ohio	5	1,433,344	5	1,667,739	+16.35
Utah	3	868,312	3	867,433	− .10
Other States a	15	7,283,934	16	8,632,084	+18.51
Total	110	82,438,096	113	92,097,131	+11.72

a Alabama, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia in 1912, with Arizona additional in 1913.

SHIPMENTS OF PORTLAND CEMENT.

State.	1912				1913			
	Shipping Plants.	Quantity (Barrels).	Value.	Average Price per Barrel.	Shipping Plants.	Quantity (Barrels).	Value.	Average Price per Barrel.
Pennsylvania	26	27,539,076	$18,918,165	$0.687	23	28,060,495	$24,268,800	$0.865
Indiana	5	9,634,582	7,237,591	.751	5	10,219,492	10,218,867	1.000
California	8	6,093,790	8,215,894	1.348	7	6,018,262	8,896,734	1.478
New York	7	4,543,060	3,448,735	.759	8	5,136,334	4,801,607	.935
Illinois	5	4,602,617	3,444,085	.748	5	4,734,540	4,784,696	1.011
Missouri	5	4,614,547	3,700,776	.802	5	4,485,820	4,556,822	1.016
New Jersey	3	4,490,645	3,052,098	.680	3	4,255,015	3,638,755	.855
Michigan	11	3,651,094	3,145,001	.861	11	4,081,281	4,228,879	1.036
Iowa	3	3,190,354	2,790,396	.875	3	3,455,800	3,972,876	1.150
Kansas	12	3,592,148	2,815,113	.784	10	3,291,818	3,286,861	.998
Texas	4	1,759,730	2,058,224	1.170	4	2,108,737	2,663,063	1.263
Washington	3	1,438,137	2,012,785	1.399	5	2,023,172	2,853,260	1.410
Ohio	5	1,382,923	1,166,589	.844	5	1,631,055	1,721,423	1.055
Utah	3	760,668	937,119	1.232	3	950,469	1,233,421	1.298
Other States a	17	7,719,135	6,167,229	.799	16	8,237,087	7,980,911	.969
Total	117	85,012,556	69,109,800	.813	113	88,689,377	89,106,975	1.005

a Alabama, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia in 1912, with Arizona additional in 1913.

It will be noted that the reports now give both production and shipments of Portland cement, and in this way throw a much more accurate light upon the industry as a whole and give better opportunities for making forecasts as to future years, as stocks in hand are thus indicated.

In connection with the matter of forecasts, the question of prices is of interest, and it will be noted that 1913 shows an increase over 1912 in a marked degree, and while Fig. 2 dealing with range in prices 1890 to

1913 shows a continuously declining curve the 1913 figures throw a little more hopeful light upon this point, which has been a discouraging one to the trade, and which in 1911, 1912 and 1913 contributed to the insolvency and bankruptcy of many cement manufacturing companies, as did also the failure to consider, in making up costs, the important items of depreciation and obsolescence, which in a continuously running industry are of vital importance. During the year attention was called to this by a number of writers.

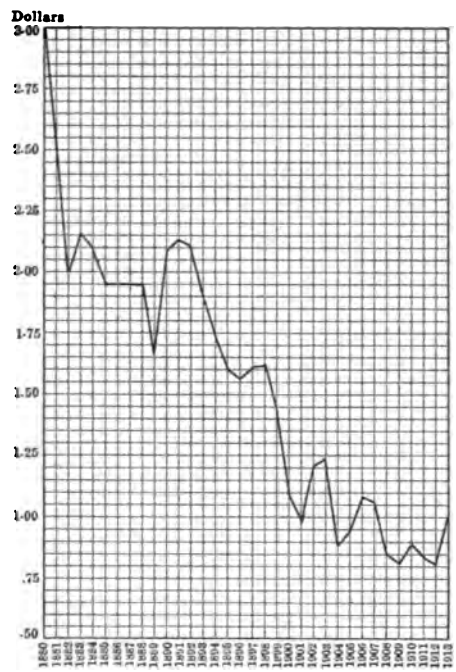

FIG. 2.—Average Price of Portland Cement

Referring to Table IV it is but fair to state that the average price of Portland cement has been increased slightly over that for the ordinary grade of Portland cement by the inclusion in the totals of some White Portland Cement valued at $2.34 per barrel. As this cement is largely produced in the Lehigh district, it has thus abnormally increased the value per barrel in that district in greater proportion than that of the other cement districts. The average price for 1913, it will be noted, was 19 cents per barrel above that for 1912 and this, in connection with the increased shipments of cement at the higher prices, may be taken as an indication of rational conditions beginning to prevail in the industry.

TABLE IV.—AVERAGE PRICE PER BARREL OF PORTLAND CEMENT, 1870-1913.

1870-1880	$3.00	1893	$1.91	1903	1.24
1881	2.50	1894	1.73	1904	0.88
1882	2.01	1895	1.60	1905	0.94
1883	2.15	1896	1.57	1906	1.13
1884	2.10	1897	1.61	1907	1.11
1885-1888	1.95	1898	1.62	1908	0.85
1889	1.67	1899	1.43	1909	0.813
1890	2.09	1900	1.09	1910	0.891
1891	2.13	1901	0.99	1911	0.844
1892	2.11	1902	1.21	1912	0.813
				1913	1.005

The distribution of the works in the various parts of the country is not only a question of market conditions, but also of raw materials and fuel supply as coal in its various forms for the calcination of cement and the production of power is one of the principal items of cost in a barrel of cement. In order to throw a further light upon these two important conditions tables are shown giving "Statistics Showing Fuel Used in Burning Portland Cement" and "Production in Barrels, and Percentage of Total Output of Portland Cement in the United States According to Type of Material Used, 1898-1913:

TABLE V.—STATISTICS SHOWING FUEL USED IN BURNING PORTLAND CEMENT

	Number of Plants.	Number of Kilns.	Output in 1913.	Percentage of Total Output.
Powdered coal	88	695	78,508,891	85.2
Petroleum	18	119	10,013,206	10.9
Gas	7	59	3,575,034	3.9
Total	113	873	92,097,131	100.0

In Table VI the raw material used are shown:

TABLE VI.—PRODUCTION, IN BARRELS, AND PERCENTAGE OF TOTAL OUTPUT OF PORTLAND CEMENT IN THE U. S. ACCORDING TO TYPE OF MATERIAL USED, 1898-1913.

Year.	Type 1. Cement Rock and Pure Limestone.		Type 2. Limestone and Clay or Shale.		Type 3. Marl and Clay.		Type 4. Blast-furnace Slag and Limestone.	
	Quantity.	Per-centage.	Quantity.	Per-centage.	Quantity.	Per-centage.	Quantity.	Per-centage.
1898	2,764,694	74.9	365,408	9.9	562,092	15.2	.....	.....
1899	4,010,132	70.9	546,200	9.7	1,095,934	19.4	.....	.....
1900	5,960,739	70.3	1,034,041	12.2	1,454,797	17.1	32,443	0.4
1901	8,503,500	66.9	2,042,209	16.1	2,001,200	15.7	164,316	1.3
1902	10,953,178	63.6	3,738,303	21.7	2,220,453	12.9	318,710	1.8
1903	12,493,694	55.9	6,333,403	28.3	3,052,946	13.7	462,930	2.1
1904	15,173,391	57.2	7,526,323	28.4	3,332,873	12.6	473,294	1.8
1905	18,454,902	52.4	11,172,339	31.7	3,884,178	11.0	1,735,343	4.9
1906	23,896,951	51.4	16,532,212	35.6	3,958,201	8.5	2,076,000	4.5
1907	25,859,095	53.0	17,190,697	35.2	3,606,598	7.4	2,129,000	4.4
1908	20,678,693	40.6	23,047,707	45.0	2,811,212	5.5	4,535,300	8.9
1909	24,274,047	37.3	32,219,365	49.6	2,711,219	4.2	5,786,800	8.9
1910	26,520,911	34.6	39,720,380	51.9	3,307,220	4.3	7,001,500	9.2
1911	26,812,139	34.1	40,665,332	51.8	3,314,176	4.2	7,737,000	9.9
1912	24,712,780	30.0	44,607,776	54.1	2,467,368	3.0	10,650,172	12.9
1913	29,333,490	31.8	47,831,863	51.9	3,734,778	4.1	11,197,800	12.2

In dealing with Table II giving the figures of the United States Geological Survey of portland cement production in the United States in 1912 and 1913, by districts (in barrels) the first factor that is interesting is that the Lehigh district, which at one time produced nearly the entire amount of Portland cement in the United States and for many years was constant at about 50 per cent. of the total output, this year produced only 27,139,601 bbl. of the 92,097,131 bbl. produced, or less than 30 per cent. of the total output, and further that while the output of the country at large increased 11.7 per cent. the increase

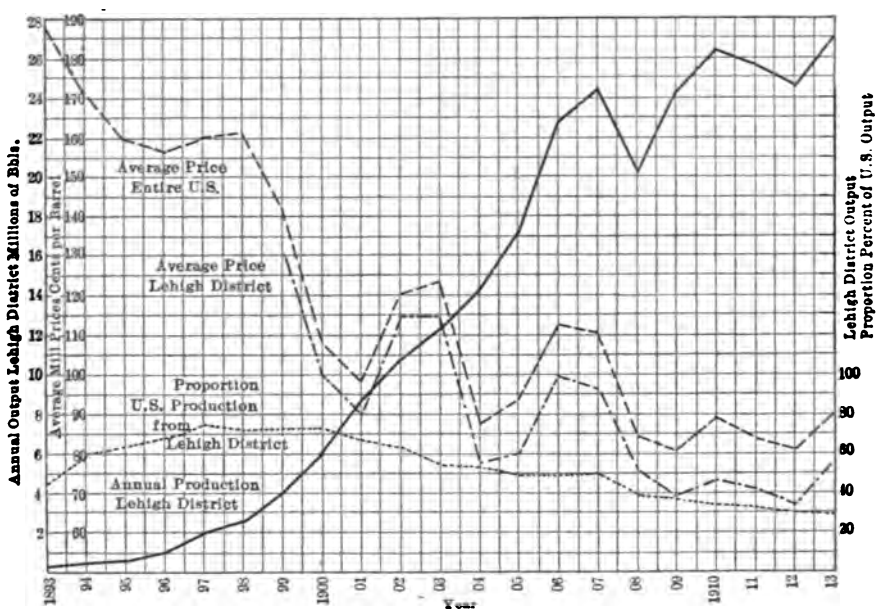
Average Price Entire U.S.
Average Price Lehigh District
Proportion U.S. Production from Lehigh District
Annual Production Lehigh District
Annual Output Lehigh District Millions of Bbls.
Average Mill Prices Cent per Barrel
Lehigh District Output Proportion Percent of U.S. Output
Year

FIG. 3.—Output and Price of Cement in the Lehigh Valley.

in the Lehigh district in production was only 9.6 per cent. and the increase in shipments 2.5 per cent. in 1913 as compared with 1912—these figures indicating that the preponderance of the Lehigh district over the country at large is slowly vanishing. One fact however must not be lost sight of in considering this statement, and that is that the seaboard shipments of the United States to foreign countries are practically all made from the Lehigh district and that in the ten months ending October 1912 3,680,000 bbl. were exported while in the 10 months ending October, 1913, only 2,640,000 bbl. were exported, making a difference of more than a million barrels. Had this export market been maintained in 1913 as it was in 1912 the Lehigh district would have shown a healthy growth,

much healthier than that shown in the Geological Survey figures. This decreased importance of the Lehigh district has been caused by the construction of plants in the South and West and on the Hudson and the figure shown here gives the results as to output and price of cement produced in the Lehigh Valley district in the last 20 years.

The general similarity of this curve of cement to the same curve in the early history of the steel industry is suggested. This figure, as given, was prepared by Hermann V. Schreiber, Consulting Engineer, Philadelphia.

The results indicated by the above table are also corroborated by the figures shown in the Annual Report of the Secretary of Internal Affairs for the State of Pennsylvania, where some most interesting figures are brought out which give the market value of the 19,922,747 bbl. of Portland cement produced in 1906 as $19,748,569, while the market value of the 26,564,694 bbl. produced in 1911 was only $19,691,609. To produce the 19,922,747 bbl. of 1906 took 10,781 laborers, while to produce the 26,564,694 bbl. of 1911 required 9916 laborers. The wages were respectively: 1906, $5,161,569; and 1911, $5,214,428. The interesting fact to be derived from these figures seems to be that the manufacturers got no more for their 26,564,694 bbl. of cement in 1911 than for their 19,922,747 in 1906, and while the labor employed in making it got a little more in wages, it produced a much greater quantity. The difference all went to the consumer, owing to the reckless competition which has been existing in this important field.

The New York State increase of nearly 16 per cent. or 700,000 bbl. on a production of 5,208,000 bbl. was no doubt largely due last year to the immense work of the Erie Canal and to road building under the great New York road building appropriation. A field which is rapidly overtaking the Lehigh district is that known as the Illinois and Northwestern Indiana district which covers the large mills of the Universal Company at Gary. The total ouput of this district in 1913 was 12,423,799 bbl. as against 10,659,357 in 1912. Running a neck and neck race in output are the Iowa and Missouri district, which embraces the large mills of the Lehigh Company at Mason City, the immense plant of the Atlas Co. at Hannibal and the great plants at St Louis, with 8,427,000 bbl. and the Pacific Coast States District with an output of 8,499,384 bbl. This latter group however while showing an increase of 15.8 per cent. in production shows an increase of only 6.9 per cent. in shipments, while an even less favorable state of affairs is shown in the Iowa and Missouri district, where the production increased 11.1 and shipments only 1.8 per cent.

On the whole the year was a surprisingly prosperous one in the industry, when the early period of 1913 is considered, and that the quan-

tity manufactured in the country should have reached nearly ninety-two and one-half millions, an increase of nearly ten millions over 1912 is a wonderful tribute to the great value of Portland cement as a building material, and its constantly widening consumption in this country.

Exports and Imports

Tables showing imports for a period of from 1878 to 1913 are of interest, and show that the high point of imports was reached in 1895 and that since 1908 imports have been steadily falling until in 1912 the lowest point was reached, the comparative figures being 2,997,395 in 1895 and 68,503 in 1912.

TABLE VII.—IMPORTS OF FOREIGN CEMENT, 1878–1913, IN BARRELS OF 380 LB.

1878	92,000	1890	1,940,186	1902	1,963,023
1879	106,000	1891	2,988,313	1903	2,251,969
1880	187,000	1892	2,440,654	1904	968,409
1881	221,000	1893	2,674,149	1905	896,845
1882	370,406	1894	2,638,107	1906	2,273,493
1883	456,418	1895	2,997,395	1907	2,033,438
1884	585,768	1896	2,989,597	1908	842,121
1885	554,396	1897	2,090,924	1909	443,888
1886	915,255	1898	1,152,861	1910	306,863
1887	1,514,095	1899	2,108,388	1911	164,670
1888	1,835,504	1900	2,386,683	1912	68,503
1889	1,740,356	1901	939,330	1913	81,403

The exports of cement during the period from 1900 to 1913—our exports beginning at a much later period than our imports—show a steadily growing figure, though it is but fair to state that a considerable portion of the 1911, 1912 and 1913 exports were shipments to Panama for the Panama Canal, which took many million barrels, and to Porto Rico, Cuba and Brazil, where preferential duties in favor of American cement prevailed.

TABLE VIII.—EXPORTS OF CEMENT, 1900–1913, IN BARRELS

Year.	Quantity.	Value.	Percentage of Total.	Year.	Quantity.	Value.	Percentage of Total.
1900	100,400	$225,306	0.6	1907	900,550	$1,450,841	1.7
1901	373,934	679,296	1.9	1908	846,528	1,249,229	1.6
1902	340,821	526,471	1.3	1909	1,056,922	1,417,534	1.6
1903	285,463	433,984	0.95	1910	2,475,957	3,477,981	3.2
1904	774,940	1,104,086	2.4	1911	3,135,409	4,632,215	3.9
1905	897,686	1,387,906	2.2	1912	4,215,532	6,160,341	5.1
1906	583,299	944,886	1.1	1913	2,964,358	4,270,666	3.2

World's Markets

From partially completed figures for 1913 the German production is estimated at about 37,000,000 bbl. while England produced some

15,000,000 and France about 7,000,000 bbl. Russia is rapidly becoming a large producer and the Scandinavian countries, Norway, Sweden and Denmark, are also advancing in the field. A rough estimate of the world's consumption of portland cement places it at about 200,000,000 bbl.

Next to the United States it will be noted that Germany is the greatest producer, but the big fact remains that the United States, which only started to produce cement in a large way in the early nineties, is today manufacturing more than all the rest of the world put together. In considering the world's industry, it must be realized that construction in European countries is permanent and of substantial, solid materials. Streets, sewers, water works, buildings, railroad terminals, etc., have been built for many years, and in some cases for many centuries, and fireproof construction is practically universal. With these facts in view it can be readily seen why in a new country like ours, where most of our early temporary construction of wood and other flimsy materials has had to be rebuilt and where many large engineering works have to be done, that the demand for a building material like cement has grown by leaps and bounds while in Europe the growth has been slower. On the other hand, it must not be forgotten that owing to the enormous shipping tonnage of European nations and the wonderful world markets that they control that England, Germany and Belgium are practically the largest exporting nations of the world, and that by this export business competitive conditions in home markets are largely relieved. In Germany and England competitive conditions are also relieved by the formation in the first named country of district trusts, which in turn are connected by Cartel agreements as to shipments from district to district, and in England by a practical consolidation of the principal works into the Associated Portland Cement Manufacturers, Limited, which is the principal owner in the British Cement Manufacturer's Association.

The end of the year 1913 saw a diminution in the home markets in most of the European countries and a marked diminution in exports, especially to South American and South Africa. The general restriction of credits caused by the financial flurry produced by the Balkan War materially affected building construction in all parts of Europe as well as in South America. Inability to procure funds in the ordinary way by building mortgages at reasonable rates of interest retarded all new construction in the fall of 1913 and a very dull year in 1914 is looked for by European manufacturers.

CHALK

No crude deposits of chalk exist in the United States. The consumption of whiting and Paris white is about 100,000 tons annually. The import duty of these products is 1/4 cent per pound. The duty on ground chalk is 1 cent a pound. The following table shows the imports for fiscal years:

	English Cliffstone.		Ground Chalk.		Dry Whiting and Paris White, Pounds.	Dollars.	Whiting in Oil.	
	Tons.	Dollars.	Pounds.	Dollars.			Pounds.	Dollars.
1909.....	10,767	16,437	1,363,005	32,225	2,089,981	13,540	76	7
1910.....	8,618	12,260	2,728,382	69,203	2,868,239	16,305	17,995	220
1911.....	.....	.....	3,826,118	92,423	4,656,958	18,758	77,581	1,151
1912.....	8,522	11,167	3,809,841	88,391	3,729,155	14,578	29,047	866
1913....(a)	150,010	120,049	2,536,622	79,731	3,536,747	14,032	36,434	881

(a) Crude chalk, total.

It requires from 2700 to 2800 lb. of crude chalk to make 2000 lb. of Paris white or whiting. The margin of profit to the American manufacturers is small. The European manufacturer pays from $4.50 to $5.50 less per ton for both chalk and labor than does the American.

The increase in ocean freights caused advancing prices in the domestic market in 1912. The selling price of English chalk varies from $2.70 to $3 per ton; of French chalk from $2.90 to $3.35 per ton.

American manufacturers are Southwark Manufacturing Co., Camden, N. J., Acme White Lead & Color Works, Boston; H. F. Taintor Mfg. Co., N. Y.; G. W. MacKenzie, Phila.; Benjamin Moore & Co., Brooklyn; Stickney, Tirrel & Co., Boston.

CHROMIUM

By C. H. MaGuire

The only commercially important ore of chromium is chromite. This ore is found widely distributed in various parts of the United States, particularly in Massachussetts, Pennsylvania, Maryland, North Carolina, Wyoming and California. Almost the entire production of chromite since 1880 has come from California. Small quantities have been mined from time to time in Wyoming. The following table gives the production of chrome ores in the United States since 1900:

Year.	Quantity, (Long Tons).	Value.
1900	140	$1,400
1901	368	5,790
1902	315	4,567
1903	150	2,250
1904	123	1,845
1905	22	375
1906	107	1,800
1907	290	5,640
1908	359	7,230
1909	598	8,300
1910	205	2,729
1911	120	1,629
1912	201	2,753
1913	255	2,854

The importations of chrome ore, chromic acid, and chromate of potash are given in the following table:

CHROMATE AND BICHROMATE OF POTASH, CHROMIC ACID, AND CHROME ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES, 1907 TO 1912, INCLUSIVE. (a)

Year.	Chromate and Bichromate of Potash.		Chromic Acid.		Chrome Ore.		Total Value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		Pounds.		Long Tons.		
1907	18,171	$1,307	1,834	$403	41,989	$491,925	$493,635
1908	216,081	15,453	3,805	708	27,876	345,960	362,121
1909	537,017	28,837	7,559	1,412	39,624	460,758	491,007
1910	406,790	19,569	9,850	1,635	38,579	415,768	436,972
1911	22,408	2,159	6,789	1,349	37,540	407,958	411,466
1912	32,913	3,085	8,728	1,376	53,929	499,818	504,279
1913	18,629	1,819	5,562	1,100	65,180	622,821	625,740

(a) Bureau of Foreign and Domestic Commerce.

The quantity and value of imports of chrome yellow or green are given in the following table:

Year.	Quantity, Pounds.	Value.
1909	109,494	$19,492
1910	170,073	23,107
1911	156,586	25,029
1912	156,733	25,516
1913	161,153	24,731

The uses of chrome ores are: in the manufacture of ferro-chromium, employed for making special steels, alone or in combination with nickel, manganese, or tungsten; for lining furnaces where the corrosive action is very great; and in the manufacture of chromium compounds for use in production of pigments, dyes, mordants and tannages.

The principal sources of chrome ore in foreign countries is given in the following table:

THE PRINCIPAL SUPPLIES OF CHROME ORE. (a)
(In metric tons.)

	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913
Bosnia	147	279	186	320	310	500	332	320	250	200	.....
Canada	3,184	5,512	7,781	7,936	6,528	6,554	2,470	279	143	.....	.....
Greece	8,478	15,430	8,900	11,530	11,730	4,350	9,600	9,463	4,615	6,468	.....
India	260	3,654	2,751	4,445	18,597	4,821	9,398	1,765	3,864	2,936	.....
New Caledonia (b)	21,437	42,197	51,374	57,367	25,371	46,890	40,000	40,000	82,806	51,516	63,370
New South Wales	1,982	403	53	15	30	*Nil.*	*Nil.*	*Nil.*	150	23	.....
Rhodesia	....	....	....	3,308	7,273	12,118	37,024	40,000	47,600	62,850	63,384
Russia	16,421	26,575	27,051	16,969	25,528	10,950	22,213	(c)	(c)	21,277	.....
United States	152	125	22	109	294	364	606	208	122	204	259

(a) From the official reports of the respective countries. No complete statistics are available for Turkey or Africa. (b) Exports, except 1909 and 1910. (c) Statistics not yet available.

Chromite is a mixture of chromic oxide and ferrous oxide, in varying proportions. The chromic oxide averages from 40 to 60 per cent. though it occassionally runs as low as 10 per cent. The theoretical composition of the ore is expressed by the formula $Cr_2O_3 : FeO$. The price is based on 50 per cent. chromic oxide.

Pigments such as chrome green, Guignet's green, chrome yellow, chrome red, and chrome orange are on the market. The chrome green, chrome orange and chrome yellow are used as dyes, the chromates, and dichromates and chromium salts are used in dyeing and printing. Chromium sales make leather resistant to moisture, which property makes them valuable in tanning.

The domestic production of chrome ore comes from Shasta and Siskiyou Counties, California. The production far exceeds the demand. This ore is used mostly in furnace linings,

Foreign Countries

Africa.—Chromite deposits extend from the junction of the Malips and Olifarts rivers, southeast as far as the Steelport river. The following table gives the analysis of the ore:

	Per cent.
Cr_2O_3	51.29
FeO	23.33
MnO	0.60
Al_2O_3	2.40
MgO	4.32
Silica	4.40
Water	12.10
Phosphorus and sulphur	Trace.

Africa.—Rhodesia is the principal chrome ore-producing country. The ore is exported by way of Beria, a distance of 560 miles from the mines. The mines now being worked are found in the Selukwe district in Matabeleland in a group of hills which for many years have contributed about 10 per cent. of Rhodesia's total gold yield. During the year 1913 Rhodesia produced 5980 tons of chrome ore. The exports from South Africa for 1913 were valued at $688,580.

Canada.—The chrome ores of Canada came chiefly from Eastern Quebec. The normal output 10 years ago was from 6000 to 8000 tons, but production has now almost entirely ceased.

Cuba.—The Cuban ores are resinols or laterites in serpentine, and occur principally at Mayari, Moa, Cubitas, Taco Bay and Navas. A typical Cuban ore is represented by the following analysis: iron from 42 to 46 per cent., alumina 3 to 13 per cent., silica 1.5 to 5 per cent., chromium 1.7 to 6 per cent., nickel and cobalt 0.3 to 1.3 per cent., and phosphorus 0.015 to 0.03 per cent.

Greece.—The chromite mined in Greece comes from Pharsala. In 1910 ore to the value of $96,668 and in 1911 to the value of $2250 was exported to the United States. During 1911, 12,915 metric tons of chrome ore and in 1912, 6468 metric tons were produced in Greece. The average sale price was 43.45 francs per ton in 1911, and 35.66 francs in 1912.

Asia Minor.—Several large mines are operated in the vicinity of Mersina. The ore, containing from 51 to 53 per cent. Cr_2O_3, is exported to France and Germany. Deposits of chrome and emery are numerous in the Western provinces, particularly in Aidin, Smyrna. Until about 10 years ago the production reached 40,000 tons per annum, but recently the production has diminished to less than 4000 tons annually. This is due in part to increased production elsewhere and lack of cheap transportation facilities.

India.—The chrome industry in Mysore was completely extinguished in 1910. Baluchistan suffered a depression at this time but lately there has been a marked improvement in conditions. The principal chrome-producing localities are the Quetta-Pishin and the Zhob districts. The ore occures in masses of serpentine. The output in 1910 was 1737 tons valued at £2315; in 1911 it was 3804 tons valued at £5072; in 1912 it was 2890 tons.

New Caledonia.—The sales of chrome ore of New Caledonia are controlled by the Chrome Co., which has gradually raised the price of the ore. In 1911, 82,806 tons, in 1912, 51,516 tons and in 1913, 63,370 tons of chrome ore were exported from New Caledonia. A French company, according to a report of the U.S. Consul at Noumea, is erecting an electric smelting plant for the production of ferro-chrome, on the Yates river.

It is expected that this plant, which will utilize about 15,000 h.p., will be in full operation within 5 years.

METALLURGY

The only progress in the metallurgy of chromium has been in the production of alloys. At Trollhättan, Sweden, a secret process is used for the production of ferro-chrome. The process is carried out in electric furnaces two of which are now in operation. The output for the year 1913 was about 1200 metric tons, and this will be extended in 1914 to 2500 tons, with further extensions in 1915. The furnace requires about 1700 kw.-hr per ton of metal reduced. Four grades, containing 5, 6 1/2, 7 1/2, and 9 per cent. chromium are produced. The ore is obtained entirely from South Africa and New Caledonia.

A process has been patented for producing low-carbon ferro-chromium containing nickel by reacting on high-carbon ferro-chromium with nickel oxide. The nickel oxide is fed into a bath of calcium aluminate slag supported on the molten ferro-chromium (U. S. Pat. 1059709).

A process for decarbonizing ferro-chromium and other ferro alloys is described in Fr. Pat. 447225. The process is carried out in a drum-shaped rotating chamber so that a blast of air or oxygen can be directed throughout the entire charge. The greater affinity of carbon for oxygen at a temperature of 1000–2500 C. is the basis of a process for obtaining a low-carbon ferro-chromium from a high-carbon ferro-chromium. The process is carried out in an electric furnace of special design (U. S. Pat. 1063341).

R. M. Keeney has shown experimentally that a low-carbon ferro-chromium can be obtained directly from the ore in the electric furnace. The power consumption does not exceed 3.7 kw.-hr. per pound. Silicon and phosphorus cannot be kept low because of the strong reducing conditions. ("Electric Smelting of Chromium, Tungsten, Molybdenum and Vanadium Ores." *Trans. Am. Electrochem. Soc.*, **24**, 167.)

Goldschmidt has perfected a process for increasing the yield of chromium in the aluminothermic production of ferro-chromium. Metallic oxides (*e.g.*, cobalt, nickel, molybdenum, tungsten and vanadium) are added to the mixture of aluminum and chrome-iron ore. This results in a higher yield of the chromium contained in the ore and a more uniform composition of the ferro-chromium. Chromium oxide in the proportions of 60 parts of the oxide to 300 parts of the chrome ore have also given good results. (Eng. Pat. 18671, Apr. 14, 1912. Under Int. Conv., July 5, 1912).

A filament for electric lights has been patented in France. (Fr. Pat. 457557). This consists of a chromium compound with hydrogen, oxy-

gen, sulphur or other metalloid mixed with cellulose and carbonized at a high temperature in an atmosphere of hydrocarbon gas at reduced pressure.

BIBLIOGRAPHY

ANON.—Chromium-Nickel Resistance Wire Alloy. *Electrochem. Z.*, **20**, 65.

BRES, M.—Discrepencies between the Structure and Composition of Two Nickel-Chrome Steels. *Rev. Met.*, **102**, 787–807.

BROWN, G. H.—Note on Load Tests made on Magnesite, Chrome and Silica Brick. *Trans. Am. Ceram. Soc.*, **14**, 391–393.

BURGESS, G. K., AND WALTENBERG, R. G.—Melting Points of the Refractory Metals. *J. Wash. Acad. Sci.*, **3**, 371–378.

DONY-HENAULT, P.—Resistance of Chromium Powder for Electrical Heating. *Comp. rend.*, **156**, 66–68.

FRIEND, J. M., WEST, W., AND BENTLEY, J. L.—The Corrodibility of Nickel, Chromium, and Nickel-Chromium Steels. *Jour. Iron Steel. Inst.*, May, 1913.

GUILLETT, L.—The Transformation Points and Structure of Nickel-Chromium Alloys. *Comp. rend.*, **156**, 1774–6.

HEUBACH, A. R.—Light Green Chromium Stains. *Trans. Am. Ceram. Soc.*, **14**, 418–433.

HEZNER, L. A.—A New Chromium-bearing Basic Magnesium Carbonate. *Centr. Min.*, 1912, 569–571.

IHDE, K.—The Magnetic Susceptibility of Manganese, Chromium Manganese and Chromium. *Ann. Physik*, **41**, 829–853.

PORTEVIN, A.—Electrical Resistance and Micro-structure of two Nickel-Chromium Steels. *Rev. Met.*, **10**, 808–810.

RAUSSDEM, C. E.—Notes on Chromium Red Glaze. *Trans. Eng. Ceram. Soc.*, **11**, 29–38.

SCHILLING.—Chromium in Sponge Form. Ger. Pat. 258736.

SCOTT, H. K.—Chromiferrous Iron Ores of Greece and Their Utilization. *Jour. Iron Steel Inst.*, May, 1913.

WATSON, T. L.—Vanadium and Chromium in Rutile and Possible Effect of Vanadium on Color. *J. Wash. Acad. Sci.*, **2**, 431–434.

————. The World's Chrome Mines. *Min. Jour.*, Oct. 11, 1913.

COAL AND COKE

By A. T. Shurick

The national coal market in 1913 was characterized by the highest average price level in the history of the trade. The year will be recorded as one of satisfactory business and substantial profits; it has been a period of rejuvenation, rehabilitation, restored confidence and general optimism.

Even though the close of the year witnessed a discouraging recession in the coal markets, 1913 cannot be regarded other than satisfactory. It was a season of great momentum, replete with readjustments that give tangible evidence of substantial progress to come.

Particular significance attaches to these facts in view of the generally adverse condition prevailing in financial circles, and the restrictive, not to say radical, State and Federal legislation enacted during the year. The situation in the world's money markets has seldom been worse. Standard securities of the most reputable description depreciated to a point scarcely exceeded by the spectacular panic of 1907, while a number of powerful corporations were forced into receiverships, including representative coal operations of national prominence.

In legislative circles a determined renewal of the dissolution proceedings against the Reading company, the unexpected announcement of the Pennsylvania State Tax on anthracite and the deliberations of the Ohio Legislature regarding the screening law have all been restraining influences adverse to a more general expansion. In national affairs the abrupt passage of the new tariff and the long threatened new currency bill, finally enacted at the close of the year, had a depressing effect on general industrial conditions that must inevitably have been reflected back to the coal industry.

In the face of these grave uncertainties in commercial circles, it is, therefore, particularly gratifying to record such a substantial improvement in the fuel industry. The question arises: How has this been brought about? The self-complacement sales organizations of the large corporations are prone to ascribe it to good salesmanship, a general determination to obtain higher prices throughout the trade and a tendency to curtail production when such figures are not prevailing. The heavy increase in the output for the year does not justify the belief that there has been any important restriction in operations, while the spectacular break in the pool of the Connellsville coke operators seems to prove the fallacy of any concerted action in holding for higher prices.

But whatever the cause, the beneficial effects must not be gaged by a standard of dollars and cents. Of far greater importance is the psychological effect upon the consumer who has been brought face to face with the fact that he must be prepared to meet a constantly increasing advance in the cost of fuel. Higher mining costs, as the depths become greater, the increasing cost of labor, a gradual depletion of our coal reserves, and the necessity for a greater expenditure in mining in order to obtain a higher percentage of recovery will inevitably bring about this condition.

The production in 1913 reached a total of about 562,000,000 short tons, exceeding the previous high record of last year by more than 30,000,000 tons; of this increase about 4,500,000 is credited to anthracite. But while the general production of the country showed an almost normal increase, it is worthy of note that the output of hard coal has not advanced over the past 3 years. The tonnage in 1913 only just made up the deficiency of 6,000,000 tons, caused by the strike in 1912, and failed to reach the record mark of nearly 70,000,000 tons in 1911. The falling off was due to the abnormally mild weather prevailing over the closing months of the year, which are usually the most active of the season.

With the possible exception of the extreme Northwest, it is not probable that the reduced tariff on coal will effect any important changes in the North American markets. The only foreign competition to be anticipated in the East is from Cape Breton coals in the coastwise trade. Since these are of rather inferior quality, as compared with the better grade domestic product, and as they also carry a high freight burden, it is improbable that they will be able to enter aggressively into the local situation.

The year in coke was marked by severe fluctuations and strenuous fights between buyers and sellers of the Connellsville product. The opening prices were high, but declined sharply in sympathy with pig iron. In July the market struck a $2.50 level, and held determinedly until October when it broke violently at first, gradually easing off to a $1.75 price. It developed later, however, that this quotation was mostly on off-qualities, and the close of the year found better prices prevailing generally.

Not the least important of the year's legislation was the passage of the Sundry Civil bill carrying a "rider" exempting labor from prosecution under the anti-trust laws. This measure was regarded as adverse to capitalistic interests and was returned to Congress for reconsideration by President Taft during his tenure in office. Organized labor has yet to prove that only the unionists shall have the privilege of working and certainly interference with the production of a commodity used in inter-

state commerce is clearly an infringement upon the basic intent of the Sherman act.

While the coal markets were developing an accumulative strength with the approach of the fall buying season, the outlook in industrial circles became steadily more ominous. As early as May there were evidences of a congested condition in the world's investment market, and standard first-class securities could only be floated at a substantial sacrifice. The origin of the trouble was ascribed to the European war, following which came an abnormally large flotation of state, government, municipal, and corporation securities. Since it is mandatory on many of the foreign banks to subscribe for the issues of their respective governments, a heavy liquidation of American securities was precipitated.

Coal Markets in 1913

Pittsburgh (By B. E. V. Luty).—The year 1913 was one of heavy coal production in the Pittsburgh district, and in addition the market afforded much more satisfactory prices than the average. Of the two preceding years, 1911 had been poor both as to tonnage and prices, while 1912 was bad as to prices if not tonnage.

Several circumstances combined to make 1913 a good year. The manufacturing demand was exceptionally large, as the industries were prosperous and the iron and steel mills tributary to the Pittsburgh district turned out the largest tonnage in their history. The railroads enjoyed a heavy traffic in the raw materials and finished product of the iron industry, and had a good business in general merchandise. The lake trade was exceptionally heavy, partly because the previous season had left the Northwest with very light stocks, and partly because there was a general expectation that the wage scale settlement for the 2 years beginning Apr. 1, 1914, would prove an unusually difficult matter, possibly involving a long suspension of mining, with a consequent late opening for lake shipments in 1914.

The Pittsburgh district operators, therefore, enjoyed a heavy demand in 1913, which helped to make good prices, but that was not the only factor. The human element entered very largely. For several years the Pittsburgh district operators have felt that coal prices were too low. At the opening of the season quotations would be named predicated upon full operation and a moderate margin of profit, and then it would develop that under curtailed operation, due to lack of demand, and of men, or shortage in car supply, the cost of production would mount. Usually full allowance was not made in advance for the constantly increasing cost of mining due to governmental restrictions and safeguards thrown around

mining by the voluntary act of the operators. Before the opening of the selling season for 1913, on Nov. 4, 1912, the Pittsburgh Coal Co. promulgated prices on a basis of $1.30 mine-run. It was then that a new element appeared, for instead of the prices being cut generally in competition for contracts and spot orders, as had almost invariably been the case in immediately preceding years, the circular quotations were quite well maintained, and indeed still higher prices were obtained for a short period toward the close of the lake-shipping season.

There were lively conditions in the Connellsville coke market throughout the year, caused by the earnest effort of a group of operators to secure better prices, relative to the selling price of pig iron, than they had ever obtained before. For many years Connelsville coke had sharp ups and downs. Owing to the practice of making semiannual and annual contracts, based largely upon what chanced to be the spot market at the time, and as the spot market of a commodity which is not stocked to any extent is naturally one of wide fluctuations, it has frequently been the case that furnacemen paid high prices for their coke when they were getting low prices for their pig iron, and *vice versa*.

In the final outcome the average price of coke and the actual realized value from the acreage will be determined by the rapidity with which consumers adopt by-product coke. The trend is strongly in that direction, but coke consumption is also on the increase, and as the Connellsville seam had a life of only about 20 years or less, at the present rate of exhaustion, an interesting contest is promised. There are those who predict that the last of the Connellsville coal will be shipped to by-product ovens, instead of going through beehive ovens at the pit mouth, but the average Connellsville operator will not admit such a probability.

Boston, Mass. (By G. G. Wolkins).—Although 1913 early sagged off from the panicky conditions of November and December, 1912, yet in the main it was a satisfactory year. It was particularly so to operators as they netted higher average prices than had ever been obtained before. There was a pronounced labor shortage in most of the districts that somewhat curtailed output; here and there as in the New River field labor difficulties cropped out, and there have been weak spots in the market; but as a whole, the coal trade has enjoyed 12 months of flourishing and remunerative business.

The only conspicuous flare-up was along the Chesapeake & Ohio Ry., centering in the Kanawha and New River districts, but the actual suspension in New River lasted only about 5 days and some of the mines were not affected. Settlement came through concessions largely on the part of the operators, and July 7 practically all the mine workers were back at their places. Since then a shortage of men has been the rule in

West Virginia and in many parts of Pennsylvania, but as it turned out, very little more coal could have been absorbed than was mined, without seriously affecting prices.

The high average price of the better Pennsylvania grades was a notable feature of 1913. For these coals to command the figures they did, month after month, with no particular shortage of cars, or anything more than threatened upsets in West Virginia, has certainly been a remarkable development. Instances could be multiplied where coals from Clearfield, Somerset and Cambria Counties have made inroads on tonnage that has always been considered "fixed" for Pocahontas and New River. There has been a great light in this respect in New England during the past year. A considerable quantity of these coals of known origin has found its way into the bunkers of off-shore freighters and liners, a thing practically unheard of except in stress times.

The most marked feature of the Pocahontas and New River situation was the remarkable strength shown by the season price of $2.85 f. o. b. Hampton Roads ($1.45 at the mine). For a time in the early spring the prospect was at least doubtful, but in March, when spot prices began to be hammered hard the rival interests got together and tide-water accumulations decreased. Thenceforth the market was held in impressive fashion and 1913 was a banner year so far as returns were concerned.

There was still a deal of caution over futures, operators hoping that somehow there would come a turn, but the only turn that came was in November when it appeared that even the producers of the choicest grades were quietly looking for milder business. Unexpectedly enough hand-to-mouth buying developed to tide over, and only in late November and early December did the choicest grades appear in any volume at tidewater points in excess of contract requirements. There was a time in October when inquiry was active for Cambrias and Somersets suitable for bunker use and prices again reached $1.65, but the ordinary low-priced Clearfields were hard to sell at a dollar flat. The Atlantic seaboard was more discriminating than was formerly the case.

Hard-coal trade on the whole enjoyed a satisfactory year in New England. The mild weather in January and February enabled dealers to get through to the end of the previous season very comfortably, and while in March the market was spotty, April was not at all the disappointment that was predicted. Numerous consignees failed to get the share of minimum-priced coal that they were counting on. The originating companies proved to be well supplied with orders, and some sizes, notably broken and pea, were in relatively short supply.

Anthracite mines were worked only 4 days a week during July and August, and this curtailment had the effect of keeping inquiry active

through what are ordinarily the dullest months. To the end of December there was hardly a let-up in the urgent call for deliveries all through the fall. Large storage depots in the East were practically bare the whole season. Retail trade was exceptionally good until November when it eased off into a weather market. Boston prices were advanced three times, 25 cents each time, until Oct. 2 they were at $8.25 for nut, the 1912 high price for that size. Dealers have held closely to the policy of keeping storage as well filled as possible and those who were far-sighted enough to take extra quantities of stove when such could be had deserve credit for protecting their customers.

Hampton Roads (By J. W. Bunting).—The year 1913 has been one of the most trying to the coal shippers from Hampton Roads ports, although it has at the same time been one of the most profitable.

During the first few months of the year there was considerable difficulty experienced in getting coal forward from the mines and a number of shippers were forced to pay demurrage on vessels held up waiting for coal. Shippers were hardly over this trouble before some of the mines were idle because of the strike. This, however, lasted only a short time and effected but few of the New River operations.

The demand for coal has been good practically all the year. During the summer and fall there was a scarcity at all piers and this, of course, kept prices up. The largest shippers had great difficulty getting coal to take care of contract tonnage. The railroads attributed the shortage at tidewater during the fall to the fact that a large number of cars which had been sent West with coal for lake shipment had been tied up in the congestion on the Western roads and that great difficulty was experienced in getting them back to the mines. Car troubles during the early fall and winter are one of the greatest difficulties which the shippers at tidewater have to contend with, and this seems to be a yearly occurrence.

Considerable uneasiness has been felt by some of the smaller selling agencies at tidewater on account of a report to the effect that practically the entire New River coal field had been sold to a British syndicate. The owners of the largest interests have emphatically denied these rumors and stated that while some small operations may have been sold, that the $50,000,000 reported to have been paid for the mines, would not purchase the number mentioned as having been included in the deal.

A new enterprise put into operation in connection with the handling of coal from Hampton Roads is the storage plant recently completed at Sewalls Point. This is expected to take care of over 200,000 tons and should the occasion demand, it could be enlarged with little cost to take care of over half a million tons, with practically the same machinery now in operation there.

While there has been considerable improvement made during the year in the facilities for handling coal, 1913 has gained little credit in the matter of tonnage with these improvements, and it remains for the coming year to show whether the dumpings over the new piers will be increased in proportion to the increased facilities.

Buffalo (By John W. Chamberlin).—Buffalo ships about four-fifths of the anthracite that is handled by lake and has increased shipments during the season of 1913 by nearly one-third. The shipment for the past season is a trifle more than 5,000,000 tons, net, while the amount for 1912 was 3,925,583 tons and for 1911 it was 3,917,429 tons, this latter being the record up to that time. The cause of the slight increase in 1912 was that the mining suspension in that year cut off the supply till well into June. This means that there is a strong tendency to increase the movements by lake into the Northwest, and the limit is likely to be reached only when the maximum output of anthracite is obtained. At the same time there is a steady increase of shipment from Lake Ontario ports, most of which is confined to that immediate territory.

There has been no important change in the anthracite trade in Buffalo during the past year, either in personnel or equipment. The effort of the Government to dispossess the Delaware, Lackawanna & Western Co. of its shipping trestle at the mouth of Buffalo river, made at various intervals during the past 20 years or more, has again been laid aside temporarily, without apparently arriving at a definite settlement. The government claims to own the site and also that the mooring of craft at the trestle to load coal is a menace to navigation. The public is divided on the question. There is a move to replace the old wooden shipping trestle with a modern car dump, and one company has about concluded to make the change immediately as these frame structures are expensive to maintain and occupy excessive space.

The bituminous year as a whole has been more active and more prosperous than ever before, in spite of the dullness of the market during December. For some reason, hardly understood by even the oldest member of the trade, the demand continued strong all through the warm months, so that it was difficult to get miners to produce or cars to transport the coal as fast as it was sold. Allegheny Valley operators, who had almost despaired of ever again seeing prosperous days, sold a largely increased output at prices 30 cents above the ordinary.

It should be said in closing that figures showing the amount of coal received in Buffalo are not obtainable. Some of the rail shipping interests keep them for the purpose, chiefly of allotting cars to the mines in time of shortage, but they steadily refuse to make them public. A rough estimate of the receipts makes the anthracite 6,000,000 tons, of which

all but about 400,000 tons is shipped out again and the bituminous receipts 7,500,000 tons, of which half to two-thirds is reshipped.

Coal Movement in 1913.—The following is a summary of the shipments of bituminous coal over the 12 leading coal roads for the past 3 years in short tons:

	1911.	1912.	1913.
Bal. & Ohio[1]	35,321,771	40,525,280	36,915,385
Buf. Roch. & P.[1 2]	8,223,617	8,839,732	9,723,992
Buf. & Susq.[1 2]	1,951,256	1,810,930	1,787,551
Chesp. & Ohio[1]	16,488,024	17,296,185	17,155,233
Hunt. & Br'd. T M.[1 2]	8,031,463	7,803,773	.....
N. Y. C. & H. R. R. R.	1,148,675	1,277,180	1,352,721
N. & W. R. R.[1 2]	8,108,738	8,396,018	9,220,689
Penn. R. R.[1 3]	20,954,839	24,112,787	23,892,469
Pitts. & Lake Erie[1 2]	65,015,701	70,117,880	51,526,267
Pitts. Sha. & Nort.[1 2]	16,090,905	17,745,835	12,783,389
Virginian[1 2]	4,826,794	4,062,363	4,555,331
Western Md.	2,817,201	3,584,292	2,953,601

[1] Includes coal received from connecting lines.
[2] Includes company's coal.
[3] Does not include company's coal haul d free.

SHIPMENTS OF ANTHRACITE.
(Tons of 2000 lb.)

	1911.		1912.		1913.	
	Tons.	Per cent.	Tons.	Per cent.	Tons.	Per cent.
Reading	13,265,758	19.0	12,852,386	20.2	12,914,887	18.70
Lehigh Valley	12,603,000	18.0	11,791,601	18.5	13,011,370	18.84
N. J. Central	9,218,802	13.2	8,342,447	13.1	9,092,433	13.16
Lackawanna	9,869,620	14.1	9,065,622	14.2	9,903,541	14.34
Del. & Hudson	7,206,731	10.3	6,361,238	10.0	7,094,258	10.27
Pennsylvania	6,494,733	9.3	7,435,697	8.7	6,351,756	9.20
Erie	8,800,179	12.6	7,435,697	11.7	8,192,352	11.86
N. Y. Ont. & West	2,495,476	3.5	2,213,382	3.5	2,509,031	3.63
Total	69,954,299	100.0	63,610,587	100.0	69,069,628	100.00

Norfolk & Western Ry.—The following is a statement of the tonnage shipped over this road during December, 1913, and the twelve months, as compared with corresponding periods of 1912 in short tons:

	December.		Twelve Months.	
	1912.	1913.	1912.	1913.
Coal.				
Tidewater, foreign	84,083	150,886	1,343,311	1,542,950
Tidewater, coastwise	258,216	331,829	3,583,283	3,805,847
Domestic	1,355,189	1,353,108	17,716,575	18,543,672
Coke.				
Tidewater, foreign	.....	575	52,762	31,082
Domestic	134,763	116,730	1,416,856	1,499,302
Total	1,832,251	1,953,128	24,112,787	25,422,853

Chesapeake & Ohio Ry.—The following is a comparative statement of the coal and coke traffic from the New River, Kanawha and Kentucky districts for December and the 6 months ending Dec. 31, 1912, and 13, in short tons:

	December.		Six Months.			
	1913.	1912.	1913.	Per cent.	1912.	Per cents
Destination,						
Tidewater	301,113	223,833	1,614,503	17	1,690,591	20
East	224,684	251,819	1,254,609	14	1,215,205	15
West	849,714	724,867	5,681,077	62	4,947,470	61
Total	1,375,511	1,200,519	8,550,189	.....	7,853,266	.....
From Connections,						
Bituminous	62,856	65,984	624,276	7	241,671	3
Anthracite	681	1,541	8,370	.....	6,971	1
Total	1,439,048	1,268,044	9,182,835	100	8,101,908	100
Coke	33,079	23,544	180,997	.....	134,936	.....

Imports and Exports.—The rapid growth of this country's export trade is steadily commanding more attention. By many of the conservative interests it is thought that a foreign outlet for the domestic product may solve the problem of the excessive productive capacity under which the industry has always labored. This is of particular interest at the present time due to the near approach of the opening of the Panama Canal which is expected to give added momentum to the country's foreign coal trade. Imports and exports for 1911–12–13 were as follows, in long tons:

	1911.	1912.	1913.
Imports from:			
United Kingdom	9,278	8,697	6,141
Canada	980,174	1,404,139	1,096,924
Japan	16,031	30,621	117,483
Australia and Tasmania	232,969	162,671	188,613
Other countries	356	2,222	4,696
Total	1,238,808	1,608,350	1,413,857
Exports:			
Anthracite			
Canada	3,498,980	3,615,530	4,083,333
Hungary	.....	.....	84
Other countries	55,019	73,259	70,969
Total	3,553,999	3,688,789	4,154,386
Bituminous			
Canada	10,609,587	10,433,010	13,496,190
Panama	496,830	486,309	489,761
Mexico	470,674	302,487	477,046
Cuba	1,053,703	1,152,004	1,275,538
West Indies	565,822	651,268	608,762
Argentina	.....	.....	70,048
Brazil	.....	.....	279,933
Uruguay	.....	.....	16,858
Other countries	682,138	1,434,900	1,272,621
Total	13,878,754	14,459,978	17,986,757
Bunker coal	6,667,338	7,340,100	7,700,520

PRODUCTION OF COAL IN THE UNITED STATES.
(In tons of 2000 lb.)

State.	1912(d).			1913.		
	Output.	Value at Mines.		Output.	Value at Mines.	
		Total.	Per Ton.		Total.	Per Ton.
Alabama	16,100,600	$20,829,252	$1.29	17,884,745	$24,742,404	$1.38
Arkansas	2,100,819	3,582,789	1.71	(a) 2,250,000	3,825,000	1.70
California and Alaska	11,333	26,441	2.33	(a) 3,000	6,900	2.30
Colorado	10,977,824	16,345,336	1.49	9,240,335	13,860,498	1.50
Georgia and North Carolina	227,703	338,926	1.49	(a) 300,000	450,000	1.50
Idaho and Nevada	2,964	9,313	3.14	3,000	9,450	3.15
Illinois	59,885,226	70,294,338	1.17	61,846,204	71,123,135	1.15
Indiana	15,285,718	17,480,546	1.14	(b) 17,246,565	19,000,000	1.10
Iowa	7,289,529	13,152,088	1.80	(b) 7,415,757	13,348,363	1.80
Kansas	6,986,182	11,324,130	1.62	(a) 7,400,000	11,840,000	1.60
Kentucky	16,490,521	16,854,207	1.02	(a) 19,500,000	20,685,000	1.06
Maryland	4,964,038	5,839,079	1.18	(a) 4,800,000	5,616,000	1.17
Michigan	1,206,230	2,399,451	1.99	(a) 1,400,000	2,744,000	1.96
Missouri	4,339,856	7,633,864	1.76	(a) 4,230,000	7,656,300	1.81
Montana	3,048,495	5,558,195	1.82	(c) 3,365,712	5,611,080	1.67
New Mexico	3,536,824	5,037,051	1.42	3,600,000	5,292,000	1.47
North Dakota	499,480	765,105	1.53	(a) 495,000	747,450	1.51
Ohio	34,528,727	37,083,363	1.07	(a) 37,500,000	40,875,000	1.09
Oklahoma	3,675,418	7,867,331	2.14	(a) 4,000,000	8,480,000	2.12
Oregon	41,637	108,276	2.60	48,000	122,400	2.55
Pennsylvania, bituminous	161,865,488	169,370,497	1.05	174,000,000	193,000,000	1.11
Tennessee	6,473,228	7,379,903	1.14	6,600,000	7,722,000	1.17
Texas	2,188,612	3,655,744	1.67	2,300,000	3,772,000	1.64
Utah	3,016,149	5,046,451	1.67	3,289,255	5,657,519	1.72
Virginia	7,846,638	7,518,576	0.96	8,500,000	8,585,000	1.01
Washington	3,360,932	8,042,871	2.39	3,677,946	8,569,614	2.33
West Virginia	66,786,687	62,792,234	0.94	71,600,000	69,452,000	0.97
Wyoming	7,368,124	11,648,088	1.58	7,100,000	12,050,000	1.55
Total bituminous	450,104,982	517,983,445	1.15	d 478,523,198	565,307,658	1.18
Pennsylvania anthracite	84,361,598	177,622,626	2.11	d 91,524,927	$195,181,127	2.13
Grand Total	534,466,580	$695,606,071	$1.30	d 570,048,125	$760,488,785	$1.33

(a) Estimated. (b) For fiscal year ended June 30. (d) Figures from the U. S. Geol. Survey.

Review of Coal Mining by States

Alabama (By B. M. Starnes).—The coal mines of Alabama during 1913 produced 17,500,000 tons of coal, breaking all previous records by over a million tons of coal. Had the operators not been handicapped by a serious car shortage, and had business during the last 2 months held up the production would have been at least 18,500,000 tons, as it is estimated that a million tons were lost by these two causes alone. This will put Alabama in sixth place among coal-producing states of the Union.

The number of non-fatal accidents in the Alabama mines during 1913 is approximately 133, which is about 15 per cent. less than in 1912. The fatal accidents for the year number 120, which is one less than the previous year. There was only one mine explosion during the year, that at the Acton mine of the Alabama Fuel & Iron Co. in November,

PRODUCTION OF COKE IN THE UNITED STATES.
(In tons of 2000 lb.)

State.	1912.			1913.		
	Short Tons.	Value at Mines.		Output.	Value at Mines.	
		Total.	Per Ton.		Total.	Per Ton.
Alabama	(d) 2,975,489	8,098,412	$2.72	3,562,624	$9,619,085	$2.70
Colorado	972,539	3,014,870	3.10	(d) 879,461	2,815,134	3.20
Georgia and North Carolina	111,000	388,000	3.50	(a) 100,000	350,000	3.50
Illinois	(d) 1,764,944	8,069,903	4.57	(a) 1,800,000	8,100,000	4.50
Indiana	2,616,339	12,528,685	4.43	(a) 2,700,000	12,015,000	4.45
Kansas	8,000	28,800	3.60	(a) 9,000	20,250	2.25
Kentucky	89,100	196,020	2.20	(d) 317,084	967,100	3.05
Missouri	6,000	18,600	3.10	(a) 6,000	18,900	3.15
Montana	68,400	383,040	5.60	.....	.....	.....
New Mexico	400,180	1,200,540	3.00	(a) 400,000	1,200,000	3.00
Ohio	321,000	963,000	3.00	395,000	1,185,000	3.00
Oklahoma	40,000	156,000	3.90	.....	.....	.....
Pennsylvania	(d) 27,372,018	56,054,428	2.05	27,100,000	56,368,000	2.08
Tennessee	345,000	966,000	2.80	328,000	908,560	2.77
Utah	347,356	1,076,804	3.10	314,000	989,100	3.15
Virginia	1,101,000	2,422,200	2.20	1,207,207	2,655,855	2.20
Washington	40,000	220,000	5.50	74,000	410,700	5.55
West Virginia	1,992,697	3,605,782	.....	4,000,000	7,760,000	1.94
Other States(b)	2,500,000	10,000,000	4.00	(a) 2,400,000	9,000,000	3.75
Total	43,544,351	$114,477,545	$2.63	(d) 46,311,469	$128,951,430	$2.78

(a) Estimated. (b) Includes output of by-product coke for Massachusetts, Maryland, Minnesota, New York, Michigan, Wisconsin. (c) Fiscal year ending June 30. (d) U. S. Geol. Survey figures.

in which 24 men lost their lives. The Government has placed at the Birmingham rescue station the only automobile ambulance and rescue car in the United States, and it has proved of great value in this work. Conditions at the mines for the safety of the men are improved vastly over last year, and the operators are giving more time and attention to "Safety First" than ever before.

During the winter and early spring of 1913, the market on all grades of coal was exceedingly good, though lump coal was slightly under the average in tonnage due to a rather warm winter. The operators were looking for a rather quiet summer, but they were agreeably surprised, for 1913 will long be remembered as one of the best summers in the coal business in Alabama. The great surprise of the year was the tendency of the market to lag during early fall, which is not usual in this district; it continued getting worse and worse, until there was practically no market whatever at the close of the year.

Alabama has had no labor troubles this year. Many of the large operators have voluntarily increased wages to all employees, and, as the mines have been almost constantly at work, it has kept the labor in this district well satisfied.

The dream of the coal operators in this district—water transportation from Birmingham to the Gulf—has at last come true. The Alabama &

New Orleans Transportation Co. is now operating barges from Tuscaloosa, Ala., down the Warrior River to Mobile and New Orleans.

Arkansas (By Thomas H. Shaw).—The production reported for the fiscal year ending June 30, 1913, was 1,952,461.93 tons, which was produced by 4188 miners, 316 mules and 77,785 kegs of black powder. Five companies did not report. They employ about 300 men. I estimate their tonnage at about 200,000 tons per annum, which would make the total 2,152,461.93 tons. I believe that it will be safe to say that the production for the calendar year will exceed 2,250,000 tons.

During the last year there have been many local strikes caused by a difference of opinion as to the construction to be placed on the agreement between the miners and operators. The mine of the Scranton Anthracite Coal Co., at Montana, Johnson County, is still idle over a strike that commenced on Sept. 5.

Six fatal and 25 non-fatal accidents occurred during the fiscal year. There have been numerous minor explosions in the mines of Arkansas during the past 20 years, of which no official record has ever been made. It is of interest to note the two largest accidents which have occurred in the mines of this state, namely, that at Huntington in 1897 and that at Bonanza in 1903.

Colorado (By A. R. Tibbitts).—With the closing of the year 1913, the coal industry of Colorado is seriously hampered by a bitter coal strike. Furthermore, there are no prospects of a settlement in the near future. Both parties to the dispute are determined not to concede the one vital point on which the strike hinges, namely, recognition of the union.

In the early months of the year, during the session of the last legislature, a new coal-mining bill was submitted for passage and was referred for a revision to a subcommittee, composed of two operators, one representing the Colorado Fuel & Iron Co., the other the Rocky Mountain Fuel Co., two coal miners, one the state inspector of coal mines and the other a member of the international board of the United Mine Workers of America, representing District No. 15, and the fifth member, an acting state senator and a metal miner by calling, who was the chairman of the committee.

One of the great contentions had been the non-employment of check weighmen at the various mines. The miners were allowed, without any protest or delay, to avail themselves of the provision in the new law permitting them to select their own check weighmen.

An 8-hour law had been passed by the 19th general assembly, and before it went into effect, most of the large companies placed their mines on this basis with pay for a 10-hour day. In addition to these

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concessions, in the northern field, where the strike called in 1909 is still in progress, the operators on Oct. 15 of this year, granted a further increase in the wage scale to the underground workers amounting to 6 per cent.

In September a conference was called by the leaders of the union but was ignored by the operators, not one responding, and on Sept. 23 a strike was called, and about 85 per cent. of the men came out. In consequence, the production in October was over a half million less than in September, that month holding its own, as great activity was displayed at the mines in anticipation of the coming strike.

Shortly after the strike was called, the market price of coal went up as high as $7.25 for bituminous and $6.50 for lignite lump coal per ton. Whether there was more coal stored than was known, or the consumption of coal was curtailed by the warm weather prevailing in October and November, the prices have dropped 25 and 50 cents per ton.

During 1913 there were 167 mines operating in Colorado, producing 9,240,335 tons as compared with 11,016,948 tons in 1912. There were 889,989 tons of coke manufactured. The mines worked an average of 191.2 days and there were 13,108 men employed in the industry.

Illinois (By Martin Bolt).—Coal mining in Illinois has been making a steady, substantial advance for the fiscal years, ending June 30, 1912, and 1913. The number of short tons mined was, for the year ended June 30, 1912, 57,514,240, and for that ended June 30, 1913, 61,846,204. The output of the shipping mines, for the same years, was: June 30, 1912, 56,096,696; June 30, 1913, 60,616,416. These figures show an increase of 4,519,720 tons. From Jan. 1, 1912, to June 30, 1912, the shipping mines produced 26,574,232 tons; from July 1, 1912, to Dec. 31, 1912, 32,494,086 tons.

Figures at hand at the present time will show that the commercial or shipping mines produced in the calendar year 1912 in round numbers 59,000,000 short tons, and from the same source we find that the tonnage during the first half of the year 1913 from the same mines was 28,021,330 tons. Assuming that the same relative increase is maintained the approximate tonnage for the calendar year ending Dec. 31, 1913, will be 62,000,000 short tons.

There has been no serious labor trouble in the mines of Illinois in the year 1913, although there have been a large number of temporary suspensions of single mines. These troubles, while much to be regretted, do not materially affect the total output.

Accidents in the mines of the state heretofore have increased at about the same rate as the tonnage. The number of fatal accidents for 1913, based on former years and figures at hand, will probably be nearly 180

and may be in excess of this number; the estimate for 11 months ending Nov. 30, 1913, is 163.

The fatal accidents in the shipping mines for the years ending June 30, 1912, and 1913, are the same for both years, namely, 173; the non-fatal accidents for the same years are as follows: 1912, 792; 1913, 1016, or an increase of 28.28 per cent. As the figures for the fiscal and calendar years vary only slightly, it is fair to assume that the fatal accidents for the calendar year 1913 will be about what they were for 1912, while the non-fatal accidents will show an increase of nearly 28 per cent.

There have been six large mines opened in this state during the year, as follows: Franklin County has three and all will be large producers of coal. Christian County has two, the Illinois Midland Coal Co.'s Nos. 7 and 8, located at Kincaid, on the Illinois Midland R. R., 7 miles from Taylorville. The Nokomis Coal Co. has also put down a large mine at Nokomis, in Montgomery County. All of the foregoing are in the No. 6 seam, while Newsam Bros. have a new mine at Glasford in Peoria County, which is down to the No. 5 seam.

Indiana (By F. I. Pearce).—If the number of tons of coal produced and wages paid mine employees is any criterion, the mining industry of Indiana, as a whole, for the fiscal year ending Sept. 30, 1913, discloses a fairly gratifying condition of both miners and mine operators. Notwithstanding the fact that there were a few operations closed down the entire year and practically all of them lost either a few days, weeks or months time on account of no sale, lack of railroad cars, local strikes or other causes, the production is reported as 17,246,565 short tons, or 877,679 tons less than the largest and 3,041,987 tons more than the second largest production in the history of the state.

Of this production, 9,637,901 tons or a fraction less than 56 per cent. was mined with machines, and 7,608,664 tons or 44 per cent. by hand. This shows an increase of about 4 per cent. in the production of coal mined by machines over that of last year. And this production would have been even larger had it not been for the difficulty experienced in undercutting the coal in a number of mines in which machines were tried out. In producing this coal there were used, 526,580 kegs of black powder, 283 cases of "permissible explosives" and 52 cases of Hoynsite safety powder.

While it is true that considerable time was lost at some of the mines on account of causes other than those due to shortage of railroad cars, local strikes and the flood in March, yet the major part of the time lost may be attributed to dull trade, resulting from an open winter, an increased production and extremely sharp competition in securing a market.

Of the bituminous coal, 10,078,336 tons were consumed in Indiana, and 6,722,644 tons were shipped to other states. Of the block coal, 203,522 tons were consumed in Indiana and 242,063 tons were shipped outside, or a fraction less than 60 per cent. of the total production was consumed within the state. This shows an increase of about 2 per cent. in the home consumption of the yearly production over that of any previous year, indicating that the consumers of coal are beginning to realize more than ever, the value of Indiana fuel.

The total wages reported from the bituminous field was $15,286,-724.97, making a fraction less than 91 cents per ton for the labor cost of production. The total wages reported from the block coal field was $673,272.66 or a fraction over $1.51 per ton for the labor cost of production. These figures show a slight increase in the cost per ton for the labor for the total production of bituminous and block coal over that of any previous year.

Sixteen new mines, all of which, with the exception of two or three, will be large producers, were opened up, and eleven mines were abandoned during the year ending Sept. 30, 1913.

During the year there were 59 accidents. The most prolific causes of accidents were the following: Falling slate at the face, 18; use of explosives (including firing of shots) 15; mine cars and motors, 7; explosions of firedamp, 6; falling coal at the face, 4; falling slate on the traveling and roadways, 4; in all 54 or 93 per cent. of the total number of fatal accidents may be attributed to these causes. Of the six fatal accidents due to explosions of firedamp, three were caused by a sudden liberation of gas following the caving in of the roof and three to firedamp that had accumulated in the mine as a result of booster fans (operated by electric power), which have recently come into use in mines of this state, being allowed to stand idle.

This data does not include figures for about 450 small mines, clay and strip banks which have an estimated production of about 450,000 tons employing from 2500 to 3000 men, since these do not come under the jurisdiction of the mine-inspecting department.

Iowa (By L. E. Stamm).—The general conditions of the coal industry in Iowa for the year 1913 were very similar to those existing in 1912. Progress in the mines of the state has been, on the whole, fairly satisfactory during most of the year. However, weather conditions in the months of October, November and December were such that there was a general falling off in the demand for coal of all grades. With the exception, therefore, of the large operations having railroad contracts, the mines of the state did not work up to their capacity during the months named above.

Statistics covering the coal production of Iowa are gathered by the mine inspectors' department for the fiscal year ending with June 30 of each year. Those secured for the year 1913 show an increase of 594,929 tons over the amount produced in the state of 1912. The production for 1913 by districts with the number of miners employed in each is as follows:

COAL PRODUCTION OF IOWA FOR FISCAL YEAR 1913.

	Tons of Coal.	Miners Employed.
First District	2,813,789	6,345
Second District	2,337,708	4,777
Third District	2,264,260	4,563
Total	7,415,757 tons	15,685 employees
Coal production for year ended June 30, 1912		6,820,828
Coal production for year ended June 30, 1913		7,415,757
Gain for 1913		594,929 tons
Fatal accidents for the year 1913		24
Non-fatal accidents for the year 1913		176

Twenty-three counties in the state are listed as coal-producing. In a number of these the mining operations are conducted on a small scale and the few mines that are operating are worked only in the winter to supply the local trade. Monroe County is the largest producer of coal of all grades. Polk County ranks second and Appanosse third. Last year these three counties yielded 5,243,279 tons of coal, or more than two-thirds of all that produced in the state.

New developments in the coal industry are in progress in several of the larger counties in the state, and the mines now started will be in shape to add considerably to the output for the coming year. Some new developments have also been made in Polk County the past year, and all these point to an increase in the coal production of the state for the coming year.

Iowa had fewer fatal accidents in the mines for the fiscal year of 1913 than for many years. The number of tons of coal mined for each fatal accident was much higher than in former years. The number of non-fatal accidents for 1913 was about the same as for 1912. The majority of the accidents occurring in the mines were caused by falls of roof or slate. These were for the most part in the rooms of the miners with but few on the entries.

Considerable improvements have been made in the mines of Iowa during the past year, chiefly in the manner of transporting the coal in the mines. Many operations have installed gasoline motors, others use electrical haulage. Some of the mines of the state are equipped with electrical hoists. Mining machines have also been introduced in some of the mines, and the general tendency is toward lessening the cost of production by better equipment for handling the product.

Kansas (By Francis Keegan).—The records in the office of the State Inspector of Mines for Kansas, when completed, will show that in round numbers 7,000,000 tons of coal were produced during the fiscal year ended June 30, 1913. Basing estimates on the figures for this period, which shows a marked increase in production over former years, there is every reason to believe that the calendar year 1913, will prove to be the most prosperous in the coal-mining industry in the state's history in point of tons of coal produced, number of men employed and number of days worked. In fact there is no hesitancy in saying that a conservative estimate of the production of coal from the mines, including the strip pits, will reach 7,400,000 tons for the year ending Dec. 31, 1913.

Complete figures are not at hand, but it is estimated that at least 12,000 men worked an average of 210 days in and around the mines during the year. This in itself, is a good record, but the most gratifying part of it is that this success has been attained with a decrease in the number of lives lost.

Quite recently a number of steam shovels have entered the field and the stripping of coal by this method is progressing at a rapid rate. The production of Kansas fuel by this means will, therefore, during the next year, reach a large figure.

Kentucky (By C. J. Norwood).—Incomplete returns for 11 months of the past year indicate that the output for the year will be about 19,500,000 tons, but the estimate must be accepted with due caution. The increased tonnage is chiefly due to new development. There were no strikes of moment, but the production has been adversely affected by the interruption of traffic resulting from the Ohio Valley floods, and occasional car shortages, especially in the eastern field. There has also been much complaint of labor shortage in that section.

The coke output has increased but I would not hazard an estimate as to the amount produced. There has been a decreased number of fatalities and no explosions.

Maryland (By William Walters).—The tonnage will be somewhat smaller for 1913 than that for 1912, which was 4,085,817 gross tons, showing a decrease of 80,919 tons from that of the year 1911. The decrease is due to the fact that there were several coal mines idle during the greater part of the year. The number of employees in the mines of the state will not be materially changed from that of the year 1912, which was 5703. The average time worked in the mines of the state will be greater than in 1912, which was 245 days.

During the fiscal year beginning May 1, 1913, there have been nine fatal accidents reported up to Dec. 23. Five were caused by falls of rock and coal, and the other four by mine cars. The reports of non-fatal

accidents have increased owing to the compensation now paid through the Miners' and Operators' Coöperative Relief fund to employees who lose time on account of injuries received while discharging their duties. Before this act, there was little or no occasion to report minor accidents.

During the year, there were four strikes throughout the state, affecting four different mines, but these were only local at each of the places, and were not general strikes affecting other mines at the same time. The new child-labor law which went into effect last year is being enforced by the mining companies in the state. Children under 16 years of age who wish to be employed in or about the mines are required to obtain an enployment certificate from their parents before they have permission to work.

Michigan (By Thomas Kanary).—There are 22 mines in active operation in the state of Michigan, the majority of these being in Saginaw and Bay Counties. Two new mines were opened in the past year, one at Unionville, Tuscola County, by the Handy Bros. Mining Co., of Bay City, and one in Genesee County by the What Cheer Coal Mining Co. of the same town.

Seven mines were abandoned during the year, four in Saginaw, two in Bay and one in Shiawassee County. There were no strikes of importance. One suspension took place in September over a misinterpretation of the mining scale, but after a week's idleness work was resumed.

There were 169 accidents in and around the mines; two of which proved fatal and six were of serious nature, while 161 were not serious. As a rough estimate, I would figure that 900,000 tons of machine coal and 500,000 of pick coal were mined in 1913 in this state.

Missouri (By Geo. Hill and J. P. Hawkins).—The output of coal for 1913 will be about the same as for 1912, when it was 4,229,907 tons. The labor disputes in the coal fields were unimportant and few in number. The fatal accidents will be 50 per cent. less than last year.

Montana (J. B. McDermott).—The reported production of Montana for 1913 is larger than the output of last year, which year produced the largest tonnage on record in Montana. The larger mines were operated more steadily this year than last; there were few labor troubles or disputes and those which occurred were adjusted satisfactorily to both parties concerned with little loss of time.

Belt mine, which is the property of the Anaconda Copper Mining Co., was abandoned during this year. It has produced during the last 10 or 11 years some 2,000,000 tons of coal and employed from 200 to 600 persons. All the pumps, engines, rails and care were pulled out. The property will be leased for local supply and general commercial use.

The Cottonwood Coal Co. is opening a mine in Fergus County near

Windham at a place named Lehigh. The shaft, which is to have five compartments, has been in process of sinking since the middle of October. The Republic Coal Co., at Klein, is installing a battery of boilers in addition to those already in use. It is adding a dynamo and generator, electric pumps and mining machines to its equipment. The shaft in Musselshell County formerly owned by Jacobs & McCleary, who did but little development work in connection with it, has been sold, if all accounts are true.

A rather peculiar condition obtains in our state. Last year 100,000 tons were shipped into Montana from North Wyoming; South Wyoming delivered 400,000 tons to us, and about 300,000 tons were shipped in from British possessions; yet, we are sending coal to Washington, Idaho and Oregon, and competing with these states and Canada in the markets.

During the present year the Cottonwood Coal Co., at Stockett; the Nelson Coal Co. at Sandcoulee; the Lochray Coal Co. at Tracey; the Sand Coulee Coal Co. at Sandcoulee; James Brodie & Son at Belt; Calone & Johnson also at Belt connected with the hydroelectric line of the Montana Power Co. This power is used to run compressors, pumps, fans, drills, haulage motors, box-car loaders, shaker screens and pneumo-electric undercutting mining machines. Not only the mines but the Butte, Anaconda & Pacific R.R., which hauls the ore from the mines in Butte to the smelters in Anaconda, has discarded steam engines and runs all its trains, both in freight and passenger service, by electric motors on power furnished by the Montana Power Co.

North Dakota (By Jay W. Bliss).—The production of lignite in North Dakota for the year just closed was about 495,000 short tons as against 528,603 for the year 1912. The unusually mild weather which prevailed throughout the state in November and December is responsible for this decrease in tonnage, 30 per cent. of the total output being mined under normal conditions during these two months. It is estimated that not to exceed 20 per cent. of the total output for 1913 has been mined in the last two months of the year.

There have been in operation during the past year 105 coal mines, including a number of strip pits and small underground workings, employing on the average about 950 men during the winter and 350 during the summer. But six fatal accidents have occurred during the year. A number of small new mines were opened up during the fall of 1913, but the demand for coal has been so moderate they have not done a satisfactory business. The state has been free from any labor disturbances that could in any way affect the production.

Much valuable research work has been done at the experiment station maintained by the state under the direction of E. J. Babcock, dean of the

State School of Mines. A process for briquetting has been worked out that is very promising, and the experiments with lignite as a producer of gas for power, heat and light, have been most satisfactory. It is to be regretted that a recent fire has temporarily crippled the work of the station.

Ohio.—The tonnage for 1913 is estimated to have reached 37,500,000 tons, or an increase of about three million over the tonnage reported for the year 1912, when the output amounted to 34,444,291 tons, which at that time was the largest tonnage recorded; in 12 years the tonnage has almost doubled itself.

There will probably be very little change in the number of persons engaged in the production of coal during the year 1913. There was a shortage of labor in Jefferson County during the month of November, but this was of short duration as the weather moderated, and there was somewhat of a cessation of the unusually strong demand for coal at that time; this permitted the coal companies to handle with satisfaction the orders they had on hand, and there was, therefore, no coal shortage which, for the time being, seemed to be in store for the users of this kind of fuel.

The majority of large mines worked about full time, and the miners experienced a year of unusual prosperity, not only in time worked, but in wages accruing from the steady demand for the product of their labor.

The usual drawback of car supply manifested itself during the months of October and November, and bid fair to prove a severe handicap to the trade. This would undoubtedly have been the result but for the moderating weather which the month of December brought. This condition alleviated what might have been a severe shortage in fuel supply.

The year 1913 will record a larger number of accidents than any year since the creation of the mining department. While it is true that there will undoubtedly be a much larger increase in tonnage, the accidents have increased out of all proportion to what they should.

The fatal accidents up to Dec. 23 number 163, and by the close of the year they will probably total 170. This would represent an increase of 25 per cent. over the number of fatalities reported during 1912, when 136 occurred. Of this number over 90 will be due to falls of roof and coal; 10 to shocks from electricity; 28 were due to mine cars, an increase of 116 per cent.; six were due to explosions of powder; 15 to explosions of gas; five to mining machines and motors, and seven to miscellaneous causes; at the present writing, falls of roof and coal will show a decrease in number as compared with the year 1912.

Mine fires occurred at two of the large producing mines of the state

during the year, but with good management and careful judgment, no serious effects were caused by either, except the loss of the operation of both of them, as the fires necessitated the complete sealing of the mines.

Several new laws were enacted by the same legislature affecting the mining industry of the state, and several amendments to old laws were also passed at that time, the most important of which were one relating to the right of action in case of death in a mine; another to the use of calcium carbide in the mines and a third relative to the approaching of abandoned workings. Another most important act of this legislature was the enactment of a statute creating the industrial commission of Ohio, superseding the state liability of awards, abolishing the department of commissioner of labor, statistics, chief inspector of mines, chief inspector of work shops and factories, chief examiner of steam engineers, board of boiler rules, and the state board of arbitration, merging certain powers and duties of said departments to said industrial commission of Ohio, and granting said commission certain other powers, and repealing a number of sections formerly in force. This commission took charge of these several departments on Sept. 1, organized the work and will from now on administer and superintend the work formerly done by these different state departments.

Oklahoma (By Edward Boyle).—As the year of 1913 drew to a close the production appeared to show a substantial increase over previous years. The output was, however, somewhat curtailed by three large producers, located in Haskell County, being idle almost the entire year. These were placed in the hands of receivers in 1912 and declared to be an unprofitable mining venture under the present scale of prices for dead work. Aside from this shutdown a few of the older mines in the McAlester field suffered a loss in production on account of a squeeze which threw them idle so far as coal production was concerned for several months. The total production for the year will reach approximately 4,000,000 tons against 3,600,000 for the year 1912 or a gain of 400,000 tons. The counties producing most of this coal are Cole, Pittsburgh, Latimer, LeFlore, Haskell, Okmulgee, Tulsa and Craig. The present indications are that Pittsburgh will lead in production, as in the previous year. Okmulgee County, which is known as the Henryetta field, will no doubt take second place in point of production. Okmulgee will, however, lead the state in machine-mined coal. Owing to the measures here being practically level or with but a slight pitch, machine mining is a practicable and successful method of operation in this field.

What is known as the McAlester field, or Pittsburg County, is just the reverse, having a pitch running from 25 to 45 deg., which makes machine mining impracticable or almost impossible. This year, however,

will show a marked decrease in pea and slack coal over previous ones with a corresponding increase in lump and nut coal. The miner is, therefore, taking more care and exercising more judgment in preparing his product for market.

The total production of the different grades of coal produced in the last fiscal year which ended June 30, 1913, was as follows:

Lump, 792,995 tons; nut, 194,178; pea and slack, 532,927; run-of-mine, 2,277,799; total, 3,797,899 tons.

The gain and loss of the different grades of coal mentioned above over the year ending June 30, 1912, is as follows: Lump gained, 83,460 tons; nut gained, 13,271; mine run gained, 759,110; total, 891,841; pea and slack loss, 32,927 tons.

Oklahoma is now profiting by the strike in Colorado, which has been in the past, one of Oklahoma's strong competitors. Oklahoma coal is of good grade, which averages about 60 per cent. in fixed carbon. Several veins make excellent coke, many ovens having been built in this field but for several years these have been idle. There is no present indication of resumption of the coke industry in this field. There have been practically no changes in operating companies in the past year and but few new developments. Almost all land in Oklahoma containing coal is segregated by the National Government and leased through the Secretary of the Interior and for several years the leasing of coal lands has been discontinued.

As this is a very dangerous field, almost all mines generating large quantities of gas and the dust being of a highly explosive nature, the decrease in fatal accidents in the past year over previous periods is highly gratifying and indicates better management and regard for the mining laws. The calendar year shows the death list to be 23. These met their death from the following causes: Falling rock, 11; powder burns, 3; windy shot, 1; runaway trip, 1; killed by cars, 4; gas explosion, 1; caught by cave-in in air shaft, 1; electrocuted, 1. The total number of non-fatal accidents was approximately 94. The total number of men employed both under and above ground was 9000.

The present outlook is considered bright and extensive improvements are anticipated during the coming year.

Pennsylvania (By Frank Hall).—The great coal-producing territory of Pennsylvania maintained its annual habit of breaking all previous records of production. A careful estimate shows that the output in the bituminous region will reach the vast proportions of 174,000,000 net tons, and in the anthracite region about 91,000,000 net tons, making a total of 265,000,000 net tons. This amount equals about one-half the entire production of the United States and one-fourth the tonnage of the world.

The production in the anthracite region for 1912 was 84,361,598 net tons, and in the bituminous region 161,865,488 net tons.

The estimated production in the anthracite region for 1913 was as follows:

District	Anthracite Gross Tons
1	3,976,000
2	4,974,000
3	3,217,000
4	4,300,000
5	3,450,000
6	4,580,000
7	5,500,000
8	4,132,000
9	5,116,000
10	5,025,000
11	5,500,000
12	2,883,000
13	2,275,000
14	3,150,000
15	2,790,000
16	2,900,000
17	4,637,000
18	2,750,000
19	3,150,000
20	2,400,000
21	3,516,000

District	Bituminous Net Tons
1	5,000,000
2	8,900,000
3	3,600,000
4	4,800,000
5	6,000,000
6	6,000,000
7	6,000,000
8	5,000,000
9	7,500,000
10	4,750,000
11	8,300,000
12	6,066,000
13	4,000,000
14	7,000,000
15	6,000,000
16	7,000,000
17	6,010,000
18	4,500,000
19	8,825,000
20	6,300,000
21	7,000,000
22	5,000,000
23	6,750,000
24	6,070,000
25	6,010,000
26	5,944,400
27	4,860,000
28	5,700,146

The coke tonnage is estimated at about 21,000,000 tons. The number of employees in the anthracite region for 1913 is estimated at 180,000, and in the bituminous region at 185,000.

The number of fatal accidents in the anthracite region was 615, and of non-fatal accidents 1238. There were 526 fatal accidents in the bituminous region and 1164 non-fatal accidents. In both regions a regrettable increase in fatalities is recorded.

There is a very evident and general desire on the part of the operators to look after the safety of their employees. One prominent phase of this work is the establishment of hundreds of first-aid squads and of many rescue corps, the members of which are selected men, carefully and thoroughly drilled and supplied with the latest and most complete outfits for the successful conduct of this important work.

In the anthracite region there were strikes of brief duration in 13 of the districts. Many of these were what is known as "button" strikes. A strike of this kind has for its whole cause the objection raised by some of the employees to the employment of a few men, who do not wear the button, which is worn by members of the United Mine Workers of America as a distinctive badge. In some cases, the failure of even one man to wear a button will precipitate a strike.

In the bituminous region there were slight labor troubles and disputes

in 11 districts. In both regions the labor troubles and the occasional shortage of car supply probably reduced the production by 500,000 tons.

What results may follow from the direct mining legislation recently enacted in other states, is another problem that will confront the mining people in Pennsylvania. But notwithstanding the acknowledged uncertain elements that will be factors in the near future, there is a general feeling of hopefulness pervading the trade.

Tennessee (By George E. Sylvester).—With the data at hand at present the output cannot be accurately stated; it probably did not vary materially from that of the year before, and might be roughly estimated at about 6,600,000 tons. There appears to have been a slight falling off in the amount of coke produced, but as this tonnage is small, the total is quickly affected by a variation in the output of one or two of the principal operations.

There were no labor troubles reported during the year. Many of the mines, especially in the eastern district, report car shortage, and the time lost for this reason, especially in the busy season, was a serious handicap to a number of the mines.

The coal market in this state is largely local, and the mild weather of the fall and early winter kept the market from being as brisk as usual.

There were no serious mine disasters during the year. The number of fatal accidents which occurred was 33. The larger part of these were attributed, as usual, to falls of slate or coal. Many were classed as unavoidable, or due to the carelessness of the miner. The number while considerably larger than that of last year, which for some reason was abnormally low, does not vary greatly from that of the average of the state in the past.

There has been increased interest in first-aid work among the miners, more especially in the eastern coal field, and a highly successful first-aid contest was held at Knoxville in the fall. This was promoted largely by the miners themselves, through the Society of Tennessee Mine Foremen.

Legislation was enacted during the year requiring the keeping of first-aid supplies at mines, also in regard to the maintenance of mine-rescue corps. No change was made in the general mining law.

Utah (By J. E. Pettit).—The coal output for the state of Utah for the year 1913 is 3,289,255 short tons, an increase of 200,899 tons, or 6.5 per cent. over last year. The production of coke is 314,694 tons, compared with 347,356 tons for 1912, or a decrease of 9.4 per cent.

A shortage of railroad cars in the fall also contributed to the small per cent. of increase of coal, but during the winter months no shortage of cars has so far been experienced.

Four thousand, six hundred fifty-nine men have been employed in and around our coal mines and coke plants during the year, showing an increase of 671 men.

While a good increase has been shown in the production of the old producing mines, some of the new operations have done well, notably the Storrs mine of the Spring Canyon Coal Co., with an output of 116,000 tons; the Willow Creek, or Castle Gate No. 2 mine, with an output of approximately 54,000 tons, and the American Fuel Co., with 50,160 tons.

Seventy-six new coke ovens have been built at Sunnyside during the past year and are now in operation, making a total of 726 beehive ovens now in operation. Seventeen fatal accidents occurred during the year, or 3.64 men per thousand. Twelve accidents occurred in the mines, and five on the surface at or near the mines. This is one less fatal accident than last year, when 16 men were killed in the mines and two on the surface. As a result of the fatalities this year, there are five widows and six fatherless children. There were also 39 serious and 60 minor accidents.

The hydrocarbon output was 23,930 tons, a decrease of 9697 tons, or 2.8 per cent. due to the limited demand for this product in the Eastern market.

Washington (By James Bagley).—In the year 1910 the coal production of Washington broke all previous records, reaching a total of 3,979,569 tons. Since that time there has been a slight decrease, owing to the substitution of oil for fuel on the railroads and many of the steamers running out of Puget Sound ports. The reports received for the first 11 months of the year 1913 and a conservative estimate of the production for December added to this places the tonnage for the year at 3,677,946 tons, an increase over the previous year of 331,000 tons.

There has been little change in the ownership of properties, the largest transaction being the purchase of the Summit mine located near Cle Elum in Kittitas County by the Roslyn Fuel Co. This is being reopened.

There have been no strikes of any importance during the year, the mines at Renton and Bayne still working on the open-shop plan. There has been no change in the wage-scale agreement, which runs for 2 years, and does not expire until Sept. 1, 1914.

There have been 19 fatal accidents for the first 11 months of the year, the largest percentage of these being from falls of rock and from mine cars. The most serious accident was an explosion of gas at the Divide mine in Lewis County on Nov. 6 in which three men met their death.

The legislature of 1911 provided for the appointment of a commission to revise the laws regulating the operation of coal mines. This commission compiled a code, which was submitted to the 1913 legislature,

which failed to include it among the laws passed. This is to be deplored, as both the miners and operators were represented on this commission, and it was supposed that they had compiled a code that satisfied both.

Most of the large companies are taking an interest in rescue and first-aid work, and most of them have rescue apparatus at their mines. The Bureau of Mines foreman for the Seattle station goes to the different mines to train men in this work and in this way it is believed better results are obtained than by waiting for the men to be sent to the station.

West Virginia (By Earl A. Henry).—From the records at hand in the Department of Mines of West Virginia, the total production of coal in 1913 in this state was approximately 71,700,000 tons. There were 3,000,000 tons of marketable coke produced. Thus in the year 1913, the coal production increased about 5,600,000 tons, and the output of coke, 2,000,000 tons. It will be seen from the above figures that the production in this state has materially increased, notwithstanding the general unrest of labor.

During a period practically embracing all the first 9 months of the year, there was a strike in the Kanawha field in the mines along the Chesapeake & Ohio Ry. Moreover there was a large reduction in tonnage in the New River and Logan County fields because of the unsettled labor conditions arising out of the strike in the Kanawha field proper. Had it not been for this strike and labor troubles of like kind all along the lines of the Chesapeake & Ohio Ry., as well as in other sections of the state, the production of coal for the calendar year 1913 would have been nearly 70,000,000 tons. In other words, the labor troubles caused the production to be about 6,000,000 tons lower than it would otherwise have been.

It is somewhat generally believed by the operators that West Virginia coal will never be sold so cheaply in the future as in the past. It is thought that the producers of coal have begun to realize what it costs to produce a ton of their product and they are not disposed to sell it at a figure lower than it costs them.

The development of new mines in West Virginia in the past 12 months is remarkable. At the present time, in Logan County alone, there are about 25 new mines being opened in the Winifrede, Island Creek, and No. 2 Gas seams, and it is estimated that within the next 7 or 8 months practically every one of these 25 new mines will be shipping coal, thus adding most materially to the production of 1914.

In Raleigh County, there is also extensive development and the mines in that section, especially those on the Winding Gulf branch of the Virginian Ry. are rapidly increasing their output. The tonnage originat-

ing on the Virginian Ry. in West Virginia is now nearing the half million mark and with the new mines being opened the production should in 12 months be double. Extensive developments are also being made in the Pocahontas and Fairmont fields.

As practically 90 per cent. of the coal produced in the state passes beyond its boundaries, the prosperity of the coal industry in the state depends entirely on adequacy of transportation facilities. The railroads, especially the Chesapeake & Ohio, have failed in some cases to keep pace with the mining development.

The Coal & Coke Ry., which passes for 200 miles through a rich country, has never equipped itself to handle the traffic which would naturally develop if facilities were assured. For this reason this road, which could have made its contiguous territory one of the most important coal fields of West Virginia, now passes over coal lands the greater part of which are undeveloped.

There are working in and around the mines of West Virginia approximately 75,000 men, and there are about 900 coal mines belonging to approximately 400 different companies. There is sufficient territory already developed in these 900 mines in which to place 30,000 more men, who could increase the output of coal at least 20,000,000 tons per year. Of course, there would have to be improvement in the car supply. In my opinion, within the next 18 months or 2 years, when the mines now developed have been put into completed operation, West Virginia will have place, not only for the 30,000 men to which I have referred, but for 10,000 more. If this accretion of mining force and a like improvement of railroad facilities were secured, West Virginia could double its production in the next 4 years.

Judging from the figures already on hand, the West Virginia coal-mining death toll will be approximately 310 lives. A little over 200,000 tons has been mined per life lost. There have been no serious mine accidents. The majority of deaths and injuries have been caused by falls of roof. The next most important cause is electricity and the third cause in order of frequency is mine cars. The careless handling of these and the jumping from trips in motion cause many accidents.

Wyoming (By Geo. Blacker).—Though only two less men were employed in 1913 than in 1912, the tonnage dropped from 5,500,253 to 5,229,817. It did not, however, fall below the output of 1911. The number of men killed fell from 35 to 21 and the number of injured from 120 to 65. Even the deaths from falls of roof and coal dropped 50 per cent.

The year ending Sept. 30, 1913, was entirely free from labor troubles and disasters. Labor has been in constant and steady demand. The

percentage of fatal accidents has decreased to a point lower than at any time during my official term as inspector of coal mines. I am receiving the active coöperation of the mine managements in all precautions I recommend them to take. Not only do they coöperate with me, but many of them go farther and take the initiative in devising means for reducing injuries and fatalities to a minimum. This is notably so with some of the larger companies, which are sparing no expense to bring about conditions of safety.

Much experimenting has been done with permissible powders with varying results. When the coal is fragile or brittle, the force of the blast has the effect of shattering it into slack and thereby rendering it unfit for commercial purposes. On the other hand, a hard, tough coal is best mined with such high-powdered explosives, because more force is required.

COAL PRODUCTION IN THE CHIEF COUNTRIES OF THE WORLD.
(In metric tons.)

Countries.	1909.	1910.	1911.	1912.	1913.
Asia:					
China	12,840,000	(e)13,190,000	(e)13,000,000	(e)13,000,000	(e)14,000,000
India	11,870,077	12,240,744	12,715,534	14,951,445	15,744,423
Japan	14,019,626	15,681,324	17,632,710	19,515,285	.....
Australasia:					
New South Wales	8,132,196	8,304,284	8,836,464	9,885,815	10,587,734
New Zealand	1,941,827	2,210,546	2,100,508	2,177,615	.....
Other Australia	1,183,875	1,710,930	.....	.....	.....
Europe:					
Austria Hungary(c)	49,509,016	47,943,109	49,859,655	52,521,776	43,743,000
Belgium	23,561,125	23,916,560	23,053,540	22,972,740	22,858,450
France	37,971,858	38,349,942	39,229,591	41,308,580	(e)42,671,000
Germany(c)	217,322,270	222,375,076	234,521,254	255,810,094	(c)278,627,497
Italy	395,600	562,153	557,137	663,812	.....
Russia	24,083,000	24,026,000	28,007,239	30,641,163	25,772,700
Spain	3,520,000	4,057,532	3,915,672	3,126,006	.....
Sweden	250,000	302,786	311,809	360,291	363,965
United Kingdom	263,774,822	268,676,528	276,332,960	257,136,000	292,202,067
North America:					
Canada—					
Western	4,245,856	6,446,336	5,500,000	6,684,161	7,072,051
Eastern	5,200,777	6,564,930	6,602,000	8,801,216	8,801,216
Mexico	919,338	2,450,000	.....	.....	.....
United States	402,981,688	445,816,040	455,720,550	534,466,580	562,595,519
South Africa(a)	4,940,192	6,508,383	7,045,805	7,365,770	.....
Other countries (e)	5,000,000	.....	5,000,000	5,000,000	.....
Totals	1,093,663,143	1,151,333,203	1,189,647,668	1,273,149,943	.....

(a) Transvaal, Natal and Cape of Good Hope. (c) Includes lignite. (e) Estimated. (f) Includes a part of Finland. (g) Gross tons. (h) Short tons.

Coal in Foreign Countries.

Australia.—The production of coal in New South Wales which represents the bulk of the Australian output, reached a total of 10,414,165 tons, valued at £3,770,373. This represents an increase of over half a million tons, and over £100,000 in value as compared with the previous year. The coal exports from Australia for 1913 were valued at £1,121,000 as against £1,147,000 in 1912 and £901,000 in 1911. During the first

9 months of 1913, exports from Newcastle totaled 3,786,432 tons, showing an increase of 166,756 tons over the same period in 1912.

In New Zealand some interesting data was published during the year regarding the coal resources of that district. These were as follows: Brown coal, 520,000,000 tons; pitch coal, 306,000,000 tons; bituminous coal (this is confined entirely to the West Coast) 254,000,000 tons. In view of the comparatively limited resources, there was some agitation in government circles to provide for conservation of the coal. Among the more important developments in the Australian fuel industry during the year was the starting of plans for largely increasing the bunkerage facilities at Newcastle.

Austria.—The Austrian coal production for 1913 amounted to 16,336,602 tons as compared to 15,663,821 tons in 1912; briquettes manufactured amounted to 196,212 tons as compared with 156,774 tons in 1912, and coke produced amounted to 2,584,281 tons as against 2,307,995 tons in 1912. The Ostrau-Karwin district leads in the coal production with 9,382,352 tons, with the Kladno, Pilsen and Galicia following in the order named. The Ostrau-Karwin district is also the leader in coke manufacturing, while the Brux-Teplitz Komotau is the largest producer of lignite coal having an output of 18,529,072 tons in 1913 as compared with 17,878,136 tons the year before. The full gross production of Austria in 1913 was 48,992,160 short tons of coal, including both bituminous coal and lignite.

Of the total coal production of Austria in 1913 the Kingdom of Bohemia is credited with 30,223,200 tons.

The total imports of coal during 1913 were 13,689,149 tons as compared with 11,848,535 tons in 1912 over 12,750,000 tons of the 1913 imports coming from Germany, the balance from Great Britain, Holland, Russia and the United States. Imports of lignite, coal in 1913, amounted to 33,097 tons; coke 933,669 tons and briquettes 263,241 tons.

Exports of coal for 1913, amounted to only 708,975 tons, while lignite exports totalled 7,016,606 tons as compared with 7,442,392 tons in 1912; practically all of the lignite exports are to Germany. Coke exports amounted to only 369,802 tons and briquettes 142,169 tons.

Belgium.—The coal production of Belgium in 1913 amounted to 22,858,450 metric tons, as compared with 22,972,740 in 1912. The output over the last half of the year was heavily curtailed, showing a decline of 211,270 tons over the previous year, as compared with an increase of 86,260 tons during the first half. In 1913, there were 147,003 workmen employed as compared with 142,913 in 1912. During the past few years, the Belgium coal production has been showing a decline, the figures for 1913 being the lowest since 1905. The Hainaut Province

continues by far to be the leading coal producing district, over 16,000,000 tons of the 1913 production having come from that province.

Exports of coal in 1913 totaled 4,943,600 tons as compared with 5,058,000 in 1912, the respective imports for the same periods being, 8,874,345 tons in 1913 and 8,132,014 tons in 1912. The imports of coal from both Germany and Great Britain showed substantial increases, while the tonnage from France fell off nearly half a million tons. Coke imports increased from 1,242,000 in 1912 to 1,466,500 in 1913, and the coke exports increased from 1,320,200 in 1912 to 1,455,200 in 1913. The gross imports in 1913 totaled 10,760,000 tons as compared with 9,767,200 tons in 1912; the respective exports for the same periods being 6,979,500 and 6,939,300.

Canada.—The coal production of Canada shows a moderate increase in 1913 over 1912, though by no means as much as 1912 made over 1911, the figures for the 3 years being 15,115,089 tons in 1913; 14,512,829 tons in 1912, and 11,323,388 tons in 1911. The continuation of the labor troubles at the mines on Vancouver Island was responsible for a falling off in the production of British Columbia, and the Province of Saskatchewan also recorded a slight falling off. But these decreases were more than compensated for by substantial advances in Alberta, and the eastern province of Nova Scotia. The gross value of the entire production in 1913 was $36,250,311 as compared with $36,019,044 in 1912.

Exports in 1913 amounted to 1,562,020 tons valued at $3,961,351 as compared with 2,127,133 tons, valued at $5,821,593 in 1912. The total imports in 1913 amounted to 18,201,953 tons, valued at $47,949,119 as compared with 14,595,810 tons, valued at $39,478,037 in 1912. The apparent consumption in 1913 amounted to 31,500,000 tons as compared with a trifle less than 27,000,000 in 1912, over one-half of the 1913 coal being imported.

The coke business showed a moderate increase during 1913, the total manufacture for that year being 1,571,133 short tons as compared with 1,406,028 tons in 1912. Nova Scotia continues far in the lead in the manufacture of coke with Ontario second, this latter product being manufactured entirely from imported coal. At the by-product coking plants in the dominion, it is estimated that $866,150 worth of by-products were recovered. The imports of coke increased from 628,174 tons in 1912 to 723,906 tons in 1913, while the exports still continue relatively insignificant.

China (By T. T. Read).—The coal output of China continues to increase. Accurate statistics for the whole country are not available, but the rate of growth is perhaps reflected by the increase in exports, which have been as follows: 318,124 tons in 1910, 326,610 tons in 1911, and 680,517 tons in 1912. The chief producer is the Chinese Engineering

& Mining Co., with which the Lanchow mines were consolidated in July, 1912, under the name of the Kailan Mining Administration, thus settling the long-standing dispute between the English company and the Chinese government. The output for the two groups of mines was 1,706,658 tons in 1912, but the output during November, 1913, was at the rate of 2,500,000 tons yearly. The Fustin mines, in Manchuria, are the next largest producers with 1,470,150 tons in 1912 and a considerable increase in 1913. The Ping Hsiang collierers of the HanYeh Ping Iron & Steel Co. produced 648,476 tons in 1911, but only 232,373 tons in 1912 as the cokes ovens were only in operation for 10 months in 1911 and 1 month in 1912 in which time they produced 181,283 and 29,109 tons of coke respectively. The output probably approached normal in 1913 as the blast-furnaces are now in operation again. The Peking Syndicate mines produced 549,877 tons in 1912. The Shantung Bergbau Gesellschaft Co. at Poshan and Fangtze yielded 573,677 tons; this company and the Peking Syndicate have considerably increased their output and the Chinghsing mines in Chihli, which is now producing 350,000 tons per year is also increasing its equipment. There are many other well-equipped mines for which the production figures are not available and in addition there is a considerable output by primitive native methods, the total for the country being 12,000,000 to 15,000,000 tons. A good deal of the native product is converted into coke in crude *meiler*, as the coke stands shipment better than does the friable coal.

France.—It is estimated that the production of coal in France for 1913 will amount to 42,671,000 tons, about 70 per cent. of which comes from the Nord and Pas-de-Calais districts. The Pas-de-Calais district had an output of 21,802,404 tons showing a decline of over three hundred thousand tons as compared with 1912. The Nord district, on the other hand, reported a slight increase of about fifty thousand tons, the total for the year 1913 being 7,816,593 tons. The coke output of these two districts held steady at slightly under two and one-half million tons. The production of briquettes for both districts amounted to 1,802,285 tons in 1913 as against 1,793,459 tons in 1912.

In the Southern district, which normally has a production of about three million tons per annum there was considerable new development work undertaken during the year with the result that the output was somewhat increased.

The imports of fuel in France still continue on a large scale, the year of 1913 recording an exceptional increase, the coal imports advancing from 15,974,712 tons in 1912 to 18,693,123 tons in 1913. Similar increases are also recorded in both coke and briquettes, the former advancing from 2,788,980 tons in 1912 to 3,070,036 tons in 1913. The

poor quality of the French product makes it necessary for that country to depend largely upon other sources for its fuel supply. As a result of unusual activity in the Balkan market during much of the year, the French operators met with little competition and were able to market considerably more coal than usual.

By far the greater part of the coal imports into France are from Great Britain, and the tonnage from that country experienced an almost spectacular advance of over two million tons in 1913, the imports from there being 11,257,431 tons in that year as compared with 9,022,411 tons in 1912. Belgium is the next largest importer into France with a tonnage of three and one-half million and Germany a close second. The coke imports come almost entirely from Germany, while Belgium leads as an importer of briquettes, with Germany second and Great Britain third. The importation of fuel into France is increasing very rapidly having nearly doubled in the past decade.

Germany.—German production recorded a satisfactory increase during 1913 of more than fourteen million tons, the output for that year being 191,511,154 tons as compared with 177,094,917 tons in 1912. The increase was general all along the line, the lignite production being 87,116,343 tons as compared with 82,339,583 tons in 1912 and the coke production advancing from 29,141,070 tons in 1912 to 32,167,716 tons in 1913. Although the production of coal in Germany is not making the rapid increase shown in America, it is, nevertheless, advancing with rapid strides, the past 10 years having witnessed an increase of more than seventy million tons in production.

The Ruhr district continues the leading producer; this district also shows by far the greatest increase, the tonnage advancing from 87,590,640 in 1912 in 96,791,880 in 1913. The upper Silesia district, the second largest producer in the country, produced 34,428,390 tons, showing an increase of only a trifle less than two million tons. The lignite production in the Rhine district, showed a relatively large increase from approximately five to six million tons.

The German foreign trade continues to be an important factor in the fuel industry, there being a general expansion in the fuel exports particularly. Thus, the coal and anthracite exports for 1913 reached 34,573,514 tons, showing an increase of about three and one-half million tons. Coke exports increased from 5,850,350 tons to 6,411,418 tons in 1913. Austria-Hungary continues the leading consumer of German exports with a total of 12,152,00 tons in 1913 and Holland second with 7,217,606 tons, Belgium, France, Russia and Switzerland following in the order named. France is the heaviest buyer of coke with a total of 2,354,918 tons in 1913.

The gross imports of coal into Germany and Luxemburg totaled

10,540,018 tons, as compared with 10,380,482 tons in 1912. Importations of lignite experienced a rather sharp decline from 7,266,116 tons in 1912 to only 6,986,681 tons for 1913. A slight increase is noted in the coke imports while both the coal and lignite briquettes suffered a decline. Coal imports are almost entirely from Great Britain, there being 9,209,543 tons from that country in 1913. The coke imports are almost from Belgium, the lignite and lignite briquettes are practically all from Austria-Hungary, and the coal briquettes from France and Holland.

Great Britain.—The year of 1913 in Great Britain was one of substantial if not unprecedented profits in the coal trade. The benefit accrued to miners and operators alike, the coal being marketed at a higher price than for any year since 1907, while the miners realized a higher average wage than at any time in the history of Great Britain. Production also established a new high record amounting to 287,411,869 tons as compared with 260,000,000 tons in 1912, and 272,000,000 in 1911, the previous high record for the country. Exports for the period also exceeded all previous records by a substantial margin.

One of the most interesting features in the British coal industry is the working of the minimum wage act, which has now been in practical operation for about 2 years. It is stated by a prominent labor leader that, since this law became operative, all experienced miners have received not less than $1.78 per day, whereas, previous to this time, a few received less than $1 per day, 5 per cent. less than $1.20 per day, 15 per cent. less than $1.45 per day, while 34 per cent. earned less than $1.70 per day.

While industrial strikes have been practically unknown during the year, it is generally agreed by all that this is only the lull before the storm. The close of 1914 and the early part of 1915 brings with it the expiration of all the current agreements between labor and capital throughout Great Britain, and also the temporary minimum wage act, which, it will be remembered, was enacted in 1912 and automatically expires at the end of 2 years. All kinds and classes of labor are straining every effort to accumulate as much reserve surpluses as possible, and mutual support among the different unions involved is being arranged for. The mine leaders already state that they are looking forward to one of the greatest, if not the very largest, industrial struggle in the history of the world.

In the world's coal markets, Great Britain easily maintained her supremacy, exporting 76,687,241 tons as compared with 67,035,848 tons in 1912, or an increase of over 14 per cent. In addition to this there were over twenty-one million tons used in the bunker trade and over three million tons of coke and manufactured fuel exported, bringing the total tidewater business up to nearly one hundred million tons.

This enormous proportion of exports to total production is one of the most striking features of the British coal industry. The world's coal markets have drawn heavily on the British products and at a steadily increasing rate since the beginning of the export trade. In 1875 Great Britain exported only 14 per cent. of her total production, which increased to 26 per cent. in 1900 and to 36 per cent. in 1913.

France continued the leading importer of British coal, taking twelve and three-fourth million tons in 1913, nearly two and three-fourth million tons more than in 1912. This fuel is used largely for the French Navy, but is also coming into more general application on railroads and for domestic use particularly in the seaboard towns on the western and southern shores. Average freight rates in this trade were higher during 1913 than in previous years.

Italy is the second largest recipient of British exports, taking 9,647,161 tons in 1913, an increase of nearly half a million over 1912. More than half of this tonnage comes from South Wales. Two million tons were small coal used in the railroad service, and there is also a heavy import business in domestic coal. Cardiff and Newport shipped a million and a half tons to Genoa, in 1913. Germany ranks third as an importer of British coal, being a close second to Italy with nearly nine million tons, an increase of over half a million tons in 1912. Russian imports amountd to nearly six million tons, showing an increase of one million over 1912, while Sweden took four and one-half million tons, an increase of about half a million tons.

Other countries importing more than one million tons of British coal per annum rank in importance as follows: Argentina, Spain and Canary Islands, Egypt, Denmark, Norway, Belgium, Netherlands, Brazil, Portugal, Azores and Madeira, Algeria and Austria-Hungary. The United States imported only 6250 tons from Great Britain in 1913.

Holland.—Coal imports into Holland during 1913, totaled 13,712,527 tons, an increase of nearly a million and a half tons over 1912, and two and one-half million as compared with 1911. Exports also showed a flat increase from a little over four and one-half million tons in 1912, to 5,106,287 tons in 1913. The excess of imports over exports last year (the latter being coal in transit from other continental countries) amounted to 8,606,240 tons.

India.—The year of 1913 witnessed a substantial increase in the coal production of India, the total for the year being 15,486,318 long tons, a million tons more than in 1911. About fourteen and one-fourth million tons or 97 1/4 per cent. of the entire Indian production originates in the Gondwana field. The Jherria district produces half the coal in this district. Increases were reported for practically all the provinces, the Bengal, Bihar and Orissa, having by far the greatest advance.

It is not generally understood what difficult problems the Indian mining industry is facing. Back in the Raniganj field a shaft was sunk to a depth of 1000 ft., another is sinking to something over 900 ft., while it is expected to start a third shortly to about the same depth. As a result of this development, it is expected that this district should show a rapid increase in production within the next few years. There was little change in the coal exports from India, but a flat increase in the imports, the total for the year, including coal, coke and patent fuel being 611,732 tons, or nearly double that for 1911. Imports from Great Britain decreased, while those from Japan, Natal and Australia all showed large increases.

Japan.—The fact that the Imperial Japanese government has seen fit to place an order for 150,000 tons of Fushun coal for railway use is indicative of the active demand for fuel in Japan. Nor is the importation of this foreign product looked upon with disfavor as it is now generally understood that consumption has outstripped the productive capacity of the mines. There has also been great activity in development work during the year, several new openings being already under way and others under consideration.

There have also been important new discoveries of coal reported on which development work will be started soon. These new facts regarding supplies promise to effect radical changes in the coaling centers of the empire. The gross exports for 1913 amounted to 3,840,000 tons as compared with 3,440,000 ton in 1912 and 2,923,000 in 1907.

Russia.—The Russian coal production seems to be increasing at a slower rate than consumption. Thus it is estimated that 1914 will see a production of 24 million long tons of bituminous and about six and one-third million tons of anthracite as compared with a consumption of twenty-four and one-half million and 6 million respectively, or a gross deficit of 532,000 tons of soft coal.

The Donetz Basin has been the scene of greatest activity in coal development during the past few years, its production having increased from twelve million short tons in 1900 to twenty-eight million in 1913. An estimate recently compiled by a number of the coal operators places the possible production in 1918, at 44,274,000 tons as compared with a consumption of 41,295,000 tons, leaving an amount available for export business of nearly two million tons. The Donetz Basin is by far the most important producer in Russia; this district produces 55.5 per cent. of the total consumption, 28.8 per cent. being supplied by other districts, and 15.7 per cent. imported.

Imports of coal into Russia for 1913 experienced a sharp advance from a little over five million tons in 1912, to more than seven and one-half million in 1913; coke imports increased from 753,000 to 954,000.

The production of the Ural district, although much less than the Donetz Basin, still shows an important advance in 1913, the gross production being 967,000 tons as compared with 764,000 tons the year before. The local railroad in that district will reconvert its engines for burning coal again. This will create an additional demand, and plans are already being prepared for additional development work.

South Africa.—The coal production of South Africa experienced a healthy increase of about 10 per cent. during 1913, the total output being 8,801,216 tons as compared with 8,117,078 tons in 1912. The province of Transvaal which produces more than one-half of the South African production showed an increase from 4,751,850 tons in 1912, to 5,225,036 tons in 1913, the greatest increase made by any of the districts. Natal is the second largest producer and showed an increase from 2,765,068 tons in 1912, to 2,898,726 for 1913.

The effects of the rapidly increasing production are becoming noticeable on the country's imports of fuel. Thus there was a sharp reduction in coal imports from 56,504 tons in 1912 to 42,210 tons in 1913. Exports, on the other hand, show a heavy increase from 1,593,210 tons in 1912 to 2,312,324 tons in 1913.

South America.—The most important coal fields of Chile lie to the south of Conception and vary considerably, those in the lower measures as a rule being the best. They are considered a rather good steam fuel, being estimated as about 25 per cent. less efficient than the Welsh coal, and 5 to 10 per cent. inferior to the Australian product. The production of Chile has shown a persistent increase, output in 1912 being 1,321,291 tons as compared with 1,188,063 tons in 1911. For the first 6 months of 1913, the output was 585,942 tons. It is doubtful if the production during the next few years will experience any important increase since the opening of the Panama Canal will make all of the market south of Valparaiso accessible to coal from the United States. However this will not be such a serious consideration as might be supposed since about 80 per cent. of the production is consumed by local railroad use.

The four principal coal fields in Chile are as follows: The Penco, part of the Bio-Bio River in the province of Concepcion, the Coronel and Lota lying between the Bio-Bio and Laraquete rivers (this district being one of the most important producers), the Colico between Laraquete and Pilpico rivers and the Ledu district in the province of Arauco. The thickness of the various seams differs a great deal as does also the characte of the roof and bottom.

Ecuador although not a heavy consumer of coal has been a consistent importer of the United States product, nearly 75 per cent. of the importation for 1913 having originated in that country, as compared with 65 per

cent. in 1912. The total imports for 1913 amounted to 30,891 tons as compared with 32,486 tons in 1912.

Bolivian imports practically all come from Australia and were valued at $256,000 in 1913. It is anticipated that the opening of the Panama Canal will result in coal being shipped in much cheaper from the United States than can be obtained at present, and it is believed that this will do much to stimulate consumption.

The opinion is expressed in some circles that Columbia may eventually prove to be the largest coal producer in South America after the opening of the Panama Canal. At Buena Ventura is a deep and well sheltered harbor right in the track of steamers plying in the South American trade and making a halfway coaling station between Australasia and Europe. In the course of the next year or two this port will be connected by rail with Cali in the center of the big Carboniferous territory.

Spain.—The Spanish coal production for 1912 amounted to 3,126,600 metric tons, showing an increase of 185,000 tons over the year before. About 75 per cent. of the production comes from the province of Oviedo. The coal imports into Spain amounted to 2,701,913 tons as compared with 2,322,607 tons in 1912. The respective figures for coke during the same period were 396,419 tons and 355,149 tons. The percentage of fuel imports has made a rapid increase during the past 3 years.

COPPER

By F. F. Hintze, Jr.

During the last 10 years the copper production of the world has shown a steady annual increase up to 1912 when the total exceeded 1,000,000 tons. The output of 1913 also passed the million ton mark, but fell slightly below the record of the previous year. Since 1903 more than one-half of the total world production of copper has been furnished by the United States. The importance of this country in the copper world may be seen at a glance on the curve given below, which shows the per cent. of the total output furnished by the United States during the last 10 years. During most of this period the percentage has varied but slightly, falling between the limits of 55 and 60 per cent.

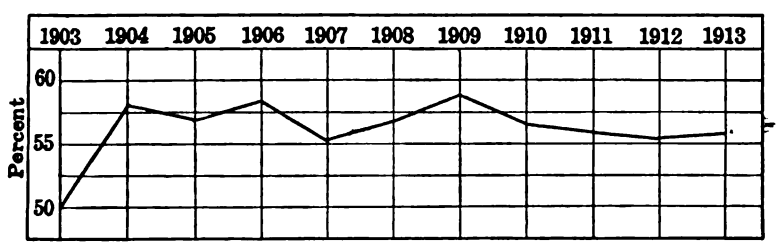

Fig. 1.—Percentage of Total Copper Output Produced in the United States.

The estimated production[1] of the American refineries in 1913 is 1,615,000,000 lb. of all classes, which exceeds the record of any previous year, as shown in the following table:[2]

PRODUCTION OF COPPER IN UNITED STATES ACCORDING TO CLASS.
(In pounds.)

Year.	Lake.	Electrolytic. (d)	Casting. (d)	Pig Copper. (a)	Total.
1906....	224,071,000	(c)860,000,000	52,000,000	29,098,000	(c)1,165,169,000
1907....	220,317,041	854,441,000	47,957,890	30,032,000	1,152,747,890
1908....	222,267,444	850,660,325	44,967,250	35,000,000	1,152,895,019
1909(e)..	226,602,134	1,101,518,458	67,471,446	43,159,018	1,438,751,056
1910(f)..	221,400,864	1,151,624,597	(g)55,673,196	46,903,463	(g)1,475,602,120
1911....	216,412,867	1,156,627,311	22,977,534	35,920,626	1,431,938,338
1912....	231,628,486	1,288,333,298	24,777,266	37,181,237	1,581,920,287
1913(b)..	161,000,000	1,390,000,000	25,000,000	39,000,000	1,615,000,000

(a) Exported. (b) Estimated. (c) Partly estimated. (d) Included copper from scrap and junk. (e) The statistics for 1909 are officially communicated to us by the Copper Producers' Association, except that to its report of 34,123,446 lb. of casting copper we have added 33,348,000 lb. reported to us by the junk smelters. The term "Lake" copper is here used to designate all copper sold in the trade as such, regardless of the process by which it is refined. (f) Copper Producers' Association, through *Eng. and Min. Journ.*, May 6, 1911. (g) Includes 23,480,000 lb. from scrap.

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

[2] Owing to some uncertainty as to the counting of copper regained from scrap, and also to the fact that the production for the last month of 1913 is partially estimated, it is unsafe to draw fine deductions from the comparison of figures in this table.

During the year 1913 the smelters of the United States produced 1,507,054,696 lb. of copper from American and foreign ores, and scrap. The bulk of this enormous production of crude copper went to the American refineries along with 173,127,139 lb. which was imported, bringing the total crude copper delivered to the home refineries up to 1,643,722,540 lb. The following table shows the smelter's production for the past 3 years:

SMELTERS' PRODUCTION.

(In pounds.)

Source.	1911.	1912.	1913.
North American ore	1,284,932,019	1,489,168,562	1,429,031,824
Foreign ore	34,392,091	53,701,307	59,234,779
Scrap	18,529,547	11,949,348	18,788,093
Totals	1,337,853,657	1,554,719,217	1,507,054,696
To foreign refiners	32,413,440	45,735,673	36,459,295
To American refiners	1,305,440,217	1,508,983,544	1,470,595,401
Blister copper imported	146,422,851	144,480,144	173,127,139
Total crude copper	1,451,863,068	1,653,463,688	1,643,722,540

A comparison of the output of the smelters with that of the refineries shows a difference of 28,722,540 lb. in favor of the smelters, for 1913. This difference was more than twice as great in 1912, but owing to a decrease in the smelter production of about 10,000,000 lb. and an increase of more than 33,000,000 lb. in the output of refined copper in 1913, it has been greatly reduced. The refiners' increase was made possible by drawing on the supply of crude copper that had accumulated from the previous years, and by the large increase in the imported crude copper. In 1911 and 1912 the stocks of copper at the smelters were reported to have been small, and with a decrease in the smelters' production and an increase for the refineries for 1913, it seems that the smelters' stock of crude copper must have been materially reduced. Unless there is a decided increase in the smelters' production for the early months on 1914 it is to be expected that the refineries will show a material decrease in their output for that period.

In the following table is given the smelters' production of copper by states, which, except in the case of Michigan where the smelters are also the refiners, is different from the refineries' output.

COPPER PRODUCTION OF THE UNITED STATES.
(In pounds.)

	1908.	1909.	1910.	1911.	1912.	1913.
Alaska	4,394,887	4,057,142	5,008,171	19,412,000	32,602,000	23,360,000
Arizona	290,167,795	292,042,829	299,606,971	300,578,816	357,952,962	401,223,786
California	36,890,353	53,357,451	45,793,894	36,806,762	31,069,029	32,206,435
Colorado	813,896,689	10,487,940	10,127,012	8,474,848	7,502,000	7,320,000
Idaho	8,749,559	7,770,010	6,216,461	3,745,210	5,964,542	8,594,722
Michigan	222,267,444	227,247,998	221,400,864	216,412,867	231,628,486	161,000,000
Montana	252,558,330	313,838,203	286,242,403	271,963,769	309,247,735	284,210,911
Nevada	12,174,269	51,835,309	63,877,500	65,385,728	82,530,608	83,829,329
New Mexico	8,523,652	5,134,506	3,632,351	1,518,288	27,488,912	48,710,000
Utah	70,978,952	100,438,543	125,042,381	138,336,905	131'673,803	148,274,658
Wyoming	2,384,356	89,654	180,861	(*b*) 130,499	(*c*) 1,121,109	(*d*) .....
Southern States	20,822,368	22,837,962	18,195,450	19,656,971	18,592,655	20,857,849
Other States	4,387,836	3,746,895	925,664	1,433,708	4,396,667	9,223,091
Total	948,196,490	1,105,336,326	1,086,249,983	1,083,856,371	1,241,762,508	1,228,811,581

(*b*) U. S. Geol. Surv. (*c*) Washington alone; Wyoming under others; in 1912, 27,570 lb. (*d*) Included under Other States.

The reports of the American smelters give the production of copper for the copper producing countries of North America during 1913 as follows:

SMELTERS' PRODUCTION OF COPPER IN NORTH AMERICA.
(In pounds.)

Country.	1911.	1912.	1913.
United States	1,083,856,371	1,241,762,508	1,228,811,581
Canada	56,370,754	75,425,575	76,250,667
Mexico	136,430,331	162,295,545	116,435,566
Cuba	8,274,563	9,684,934	7,534,010
Total	1,284,932,019	1,489,168,562	1,429,031,824

The statistics show plainly how the copper production in Mexico has been affected by the unfavorable conditions that have arisen as a result of the war which is still in progress. The output has fallen far below the record of the last few years and has not been so low during the last 10 years. The reduction in the total copper production for North America was brought about mainly through the failure of mines in Michigan to yield a normal output, and the great falling off in Mexico's rate of production. With the restoration of normal conditions in these two important fields the total for North America will show a decided increase.

Consumption.—L. Vogelstein & Co. estimate the world's copper consumption for 1913 as compared with that of previous years, as follows:

(In tons of 2240 lb.)

	1910.	1911.	1912.	1913.
Germany	208,826	234,985	253,249	265,000
France	92,838	106,408	106,753	118,000
England	148,187	159,736	148,877	145,000
Austria-Hungary	37,150	41,101	51,574	50,000
Russia	28,237	31,830	38,818	41,000
Italy	32,487	40,949	34,378	32,000
Rest of Europe	26,000	25,000	23,000	25,000
Far East	22,000	26,500	32,000	30,000
United States	334,565	316,792	365,922	342,500
Total	930,290	983,300	1,054,751	1,048,500

The following table shows the U. S. refineries' production and the deliveries for export and domestic consumption in the United States and the visible stocks in the United States and Europe for each month during 1913, as well as the totals for 1912 and 1913, according to the report of the Copper Producers' Association.

Month.	United States.			Visible Stocks.		
	U. S. Refin'y Production.	Deliveries, Domestic.	Deliveries, for Export.	United States.	Europe.	Total.
Year, 1912	1,581,920,287	819,665,948	746,396,452	.....	.....	.....
I 1913	143,479,625	65,210,030	60,383,845	105,312,582	78,491,840	183,904,422
II	130,948,881	59,676,492	72,168,523	123,198,332	77,504,000	200,702,332
III	136,251,849	76,585,471	77,699,306	122,302,890	81,244,800	203,547,690
IV	135,353,402	78,158,837	85,894,727	104,269,270	87,180,800	191,450,070
V	141,319,416	81,108,321	68,285,978	75,549,108	85,948,800	161,497,908
VI	121,860,853	68,362,571	68,067,901	67,474,225	77,235,200	144,709,425
VII	138,074,602	58,904,192	78,480,071	52,814,606	77,904,000	124,808,606
VIII	131,632,362	73,649,801	73,263,469	53,594,945	66,420,480	120,015,385
IX	131,401,229	66,836,897	73,085,275	38,314,037	63,716,800	102,030,837
X	139,070,481	68,173,720	68,123,473	29,793,094	53,625,600	83,418,692
XI	134,087,708	48,656,858	70,067,803	32,566,382	48,787,200	81,353,582
XII	138,990,421	21,938,570	73,542,413	47,929,429	46,592,000	94,512,429
Year 1913	1,622,450,829	767,261,760	869,062,784	.....	.....	.....
I, 1914	.....	.....	.....	91,438,867	53,916,800	145,355,667

Note.—Visible supplies in Europe do not include copper afloat.

The domestic supply of marketable copper on Jan. 1, 1913 was 105,312,582 lb., and the total production of refined copper for the year amounts to 1,622,450,829 lb., which makes a total of 1,727,763,411 lb. The deliveries for domestic consumption were 767,261,760 lb., and for export 869,062,784 lb., leaving a stock on hand Jan. 1, 1914 of 91,348,867 lb. This shows a decrease in the visible stock of 13,963,715 lb., as compared with the stock on hand Jan. 1, 1913. During the first 4 months of the year the stock of standard copper in the United States was greater than for any other part of the year. From May to October there was a gradual decrease in the visible supply from 75,549,108 lb., to 29,793,094 lb., which was the lowest figure for the year. November and December showed increases again, and by the first of January the supply had about reached the figure with which the year opened. The production was heaviest for January, but remained large for each month of the year. During the first 4 months the production was in excess of the demand, causing the visible supply to rise, but throughout the rest of the year the deliveries exceeded the production with the consequent reduction in the visible stocks.

The factors which influence the copper situation are the increase of the visible supply offset by the invisible supply in the hands of the con-

sumers. Manufacturers are able to shift the burden of carrying stocks to the producers, temporarily, but when their supply nears exhaustion they are forced to buy again. This condition causes the variation in the visible supply to occur and has an important bearing on the price of copper.

In the following table the consumption of refined copper is approximately shown for the past 10 years:

CONSUMPTION OF COPPER IN THE UNITED STATES. (*a*)

Year.	Production.	Stock Jan. 1.	Imports.	Supply.	Exports.	Stock Dec. 31.	Consumption.
1904...	817,715,005	230,111,792	182,292,205	1,230,119,002	555,638,552	208,376,672	466,103,778
1905...	875,241,741	208,376,672	210,724,685	1,294,343,098	548,772,403	132,587,496	612,983,199
1906...	917,620,000	132,587,496	225,593,281	1,275,800,777	467,839,041	139,385,400	668,576,336
1907...	1,152,747,890	9,000,000	5,000,000	1,166,747,890	508,929,401	120,000,000	537,818,489
1908...	1,152,895,019	120,000,000	.....	1,272,895,019	661,876,127	122,357,266	488,661,623
1909...	1,405,403,056	122,357,266	.....	1,527,760,322	682,846,726	141,766,111	703,147,485
1910...	1,452,122,120	141,766,111	.....	1,593,888,231	708,316,543	122,030,195	763,541,493
1911...	1,431,938,338	122,030,195	.....	1,555,968,533	786,553,208	89,454,695	677,960,630
1912...	1,581,920,287	89,454,695	.....	1,671,374,982	775,000,658	105,312,582	791,061,742
1913...	1,622,456,829	105,312,582	.....	1,727,768,411	926,441,142	91,348,867	709,978,402

(*a*) The statistics in the above table up to 1906 inclusive are computed in the old way, namely on the basis of the production of blister copper and the imports of copper in all forms. The stock on hand at the beginning and end of the year includes not only refined copper, but also the crude copper in transit and in process of refining. The statistics since 1906 are computed on the new and more accurate method described in *Eng. and Min. Journ.*, July 25, 1908. Briefly, in this method the basis is production of refined copper, stock of copper in final marketable form and imports of refined copper. This change in method explains the erratic appearance of the figures for 1907 as compared with those of 1906.

The production and stock on hand Jan. 1, are the same as in the preceding table, and the supply is found by adding these figures together. The exports are different from deliveries for export, and are obtained from the statistical report of the Dept. of Commerce. The supply less the exports and the stock on hand Dec. 31, gives the figures for consumption.

EXPORTS OF COPPER FROM THE UNITED STATES. (*a*)
Ore, matte and regulus stated in tons of 2240 lb. Ingots, etc., in pounds.

Country.	1908.	1909.	1910.	1911.	1912.	1913.
	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....
Ore, matte and regulus	63,149	59,880	43,784	57,915	66,171	65,684
Ingots and scrap (*b*)						
Exported to:						
United Kingdom....	117,810,314	156,511,113	98,030,213	108,061,603	95,422,292	33,679,641
Belgium.....	5,560,366	6,016,861	7,176,258	5,125,C04	7,674,273	7,102,120
France.....	115,690,381	99,003,962	116,193,850	135,038,893	131,362,694	160,000,345
Germany.....	137,453,392	138,213,290	175,861,028	190,428,008	252,156,012	307,150,761
Italy.....	25,512,267	26,386,069	34,110,237	38,216,773	47,251,432	41,568,713
Netherlands.....	195,562,619	204,378,211	221,764,806	230,693,649	152,618,177	178,940,289
Russia.....	4,657,077	3,519,216	6,848,311	15,601,688	4,961,473	7,907,672
Other Europe.....	39,433,674	41,661,979	42,203,861	9,254,363	8,960,973	14,357,014
Brit. North America	3,977,142	6,790,410	5,628,487	8,931,582	30,302,856	36,182,257
Mexico.....	35,895	46,287	.....	.....	.....	.....
China.....	13,735,899	.....	.....	.....	.....	.....
Other countries.....	2,447,101	319,328	499,492	(*c*) 45,201,645	(*c*)44,290,476	4,904,125
Total.....	661,876,127	682,846,726	708,316,543	786,553,208	775,000,658	926,441,142

(*a*) The exports of ore, matte and regulus are reported as gross weight, the copper contents not being stated. (*b*) Includes bars and plates. (*c*) Includes Austria-Hungary, 44,200,202 lb. and 38,558,151 lb. resp.

IMPORTS OF COPPER INTO THE UNITED STATES. (a)
(In pounds.)

Country.	1908.	1909.	1910.	1911.	1912.	1913.
Ore and matte						
Imported from:						
Germany	.....	.....	.....	.....	.....	1,067,024
Spain	.....	.....	.....	.....	.....	6,244,676
Cuba	.....	.....	.....	.....	.....	5,362,132
Brit. North America	11,187,297	9,689,829	10,034,806	12,919,644	28,930,073	34,072,096
Mexico	15,903,692	23,914,040	22,731,184	16,684,071	18,069,987	19,722,530
South America	13,025,614	20,987,197	19,425,233	15,305,335	26,749,545	(e)25,311,542
Other countries	16,365,340	26,496,327	33,033,752	23,717,628	31,122,098	17,712,105
Total	56,481,943	81,087,393	85,224,975	68,626,778	104,871,703	109,492,105
Pig and Scrap (b)						
Imported from:						
United Kingdom	5,434,435	26,527,574	18,649,727	9,004,461	1,404,118	17,943,285
France	168,506	490,191	.....	.....	.....	.....
Germany	1,451,370	1,045,647	.....	.....	.....	.....
Other Europe	13,359,117	27,379,175	25,411,393	28,042,257	31,670,095	(f)36,565,767
Brit. North America	30,895,737	29,196,351	29,016,785	22,442,335	36,138,255	33,749,133
Mexico	43,742,993	76,119,724	84,008,907	97,115,574	124,742,193	97,003,847
Cuba	349,560	104,182	.....	.....	.....	.....
West Indies (c)	184,490	223,408	.....	.....	.....	.....
Japan	8,329,896	23,830,140	18,482,989	20,030,447	19,511,402	14,367,493
Other countries	58,308,040	55,797,329	83,640,995	89,345,686	91,903,529	78,280,969
Total	162,224,144	240,713,721	259,210,796	265,980,760	305,369,592	300,068,849

(a) The imports reported are the copper contents of ore matte and regulus. (b) Includes also bars, ingots and plates. (c) Includes Bermuda. (d) As follows: Australia and Tasmania 24,700,333 lb.; Peru 43,891,439 lb; Chile 8,627,421 lb. (e) All from Chile. (f) All from Spain.

THE WORLD'S COPPER PRODUCTION.
(In metric tons.)

Country.	1904.	1905.	1906.	1907.	1908.	1909.	1910. (h)	1911.	1912.	1913.
Africa (a) Cape Co.	5,563	5,105	4,003	4,298	4,550	4,720	7,016	17,252	16,633	5,812
Africa (a) Namaqua	2,337	2,337	2,642	2,540	2,440	2,337				2,540
Africa (a) Other	.....	.....	.....	.....	.....	8,128	8,433	.....	.....	17,089
Argentina (a)	157	157	107	224	226	610	305	1,036	335	117
Australasia (a)	34,706	34,483	36,830	41,910	40,123	34,952	40,962	42,512	47,774	47,326
Austria-Hungary (a)	1,473	1,346	1,458	1,062	3,877	6,218	2,276	2,566	4,024	4,135
Bolivia (a)	2,032	2,032	2,540	21,035	2,540	2,032	2,540	(d) 2,950	(d) 4,681	3,658
Canada (d)	19,490	21,595	19,110	2,540	24,376	21,626	23,810	25,570	34,213	34,587
Chile (d)	31,025	29,126	25,829	28,863	42,097	42,726	38,346	33,088	39,204	40,195
Cuba (d)	.....	.....	1,384	1,388	2,966	3,006	3,538	3,753	4,393	3,517
Germany—total (a)	30,262	22,492	20,665	20,818	20,523	32,815	25,105	22,363	24,304	25,309
(Mansfeld) (a)	(19,578)	(19,878)	(18,085)	(17,343)	(18,000)	(19,015)	(20,275)	.....	.....	(20,201)
Italy (a)	3,388	2,997	2,911	3,353	3,022	2,769	3,272	2,642	2,337	1,626
Japan (f)	33,187	35,944	36,963	40,183	41,399	42,987	50,703	d) 52,303	d) 62,486	a73,152
Mexico—total (d)	51,759	65,449	61,615	57,491	38,190	57,230	62,504	61,884	73,617	52,815
(Boleo) (a)	(11,120)	(10,341)	(11,002)	(11,506)	(12,600)	(12,426)	(13,003)	.....	.....	(13,020)
Newfoundland (a)	2,235	2,316	2,332	1,758	1,453	1,402	1,097	1,174	549	.....
Norway (a)	5,502	6,406	6,218	7,122	9,337	9,226	10,592	9,576	11,156	11,796
Peru (e)	9,504	12,213	13,474	20,681	15,240	16,257	27,375	28,500	f) 26,483	d25,715
Russia (c)	9,835	9,515	9,296	15,930	17,718	18,035	22,670	25,747	33,550	42,970
Spain-Portugal (a)	47,788	45,527	50,109	50,470	53,425	53,023	51,080	51,748	59,876	54,696
Rio Tinto (a)	34,016	32,795	34,642	32,833	35,517	35,938	(34,114)	(35,100)	.....	36,901
Tharsis (a)	5,710	4,415	4,816	4,206	4,500	4,425	(3,551)	(3,450)	.....	3,270
Mason & Barry (a)	2,997	2,764	2,504	2,662	2,804	2,403	(3,003)	(2,972)	.....	3,185
Sevilla (a)	1,351	1,300	2,073	2,337	2,196	1,849	(1,656)	(1,558)	.....	1,535
Sweden (c)	533	1,385	1,209	1,577	2,808	2,032	2,032	2,032	(a) 1,524	a) 1,016
Turkey (a)	965	711	432	1,270	1,068	813	610	1,016	508	508
United Kingdom (g)	501	727	762	677	588	442	508	405	405	305
United States (d)	400,998	397,069	416,343	398,930	430,399	501,372	492,720	491,634	563,260	557,387
Total	693,240	698,931	715,510	724,120	758,065	854,758	877,494	879,751	1,011,312	1,002,284

(a) As reported by Henry R. Merton & Co., Ltd., of London. (b) As reported by Henry R. Merton & Co., previous to 1905, subsequently as reported by the *Eng. and Min. Journ.* (c) As officially reported except for 1909, for which year the figure of Henry R. Merton & Co. is used. (d) As reported by the *Eng. and Min. Journ.* (e) As reported by Henry R. Merton & Co. for 1900–1902, as officially reported 1903–1907, as per Henry R. Merton & Co. for 1908 and 1909. (f) As officially reported. (g) As officially reported, 1900–1905; subsequently as per Henry R. Merton & Co. (h) Henry R. Merton & Co., through *Eng. and Min. Journ.*

WORLD'S PRODUCTION OF COPPER. (a)

Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.
1881....	166,065	183,093	1892...	309,113	340,808	1903...	630,590	694,910
1882....	184,620	203,550	1893...	310,704	342,562	1904...	693,240	764,758
1883....	202,697	223,481	1894...	330,075	363,920	1905...	698,931	770,221
1884....	223,884	246,840	1895...	339,994	374,856	1906...	715,510	788,492
1885....	229,315	252,828	1896...	384,493	423,917	1907...	724,120	798,205
1886....	220,669	243,295	1897...	412,818	455,147	1908...	758,065	835,623
1887....	226,492	249,716	1898...	441,282	486,529	1909...	854,758	942,408
1888....	262,285	281,179	1899...	476,194	525,021	1910...	877,494	966,998
1889....	265,516	292,741	1900...	491,435	541,561	1911...	879,751	969,750
1890....	274,065	302,166	1901...	529,508	583,517	1912...	1,011,312	1,114,769
1891....	280,138	308,862	1902...	542,606	597,951	1913...	1,002,284	1,104,517

(a) The statistics for 1881–1891 are as reported by Henry R. Merton & Co.: 1892–1910 as per THE MINERAL INDUSTRY.

Statistics on the world's production of copper as given in the table are taken mainly from figures by the *Engineering and Mining Journal*, and from those compiled by Henry R. Merton & Co. In all cases the production from domestic raw products and ore only are included, and for the reason that in a few cases some of them may have been exported without recording them, the figures may be low.

The world's output of refined copper according to Henry R. Merton & Co. totaled 986,375 long tons in 1913, as compared with 1,006,110 tons in 1912, and 871,920 tons in 1911. The decrease of 19,735 tons for 1913 from the record production of 1912 is less than 2 per cent. (1.9), while the increase over 1911 is 114,455 tons, or 13.1 per cent. The heaviest loss is indicated for Mexico, and a slight decrease for the United States and Canada. The most important gains were in Chile, Russia, Japan, and Africa, the last named country being chiefly affected by the increase from the Katanga mines. The United States continues to furnish somewhat more than half of the world's supply of copper, the amount being a fraction over 55 per cent., while North America furnishes over 64 per cent. of the total.

The Selling Agencies.—A few of the producers sell their copper directly and handle only their own product. This is the practice of the Quincy Mining Co., the Wolverine and Mohawk, the Franklin and the Mass companies, in the Lakes region. Other companies handle more copper than they produce, selling on a commission basis. Thus, the Calumet & Hecla sells the copper of the other Lake companies in which it is a stockholder, the Osceola, Allouez, Ahmeek, Superior, Tamarack, Isle Royal, and Centennial. The American Smelting & Refining Co. disposes of the output of the Cerro de Pasco, Utah Copper Co., Nevada Consolidated, Tennessee Copper, Ray Consolidated, Chino, Mason Valley and Ohio Copper companies, besides its own. The United Metals Selling Co. is agent for a number of companies among which are the Anaconda and North Butte, Copper Range, Arizona

Copper Co., Greene-Cananea, and Giroux. Phelps Dodge & Co. disposes of the products of the Copper Queen Smelter, the Detroit Copper Co., and the Calumet & Hecla. Other important agencies are the American Metal Co., L. Vogelstein & Co., E. P. Earle; Beer, Sondheimer & Co., Adolph Lewisohn & Sons, and W. Parsons Todd. Of these agencies, the American Smelting & Refining Co. is the greatest distributer of refined copper, having disposed of 494,600,000 lb. in the past year.[1] The next most important agency is the United Metals Selling Co. with a production of 442,000,000 lb. to distribute. Then follow Phelps Dodge & Co. with 209,000,000 lb., and the American Metal Co., and L. Vogelstein & Co. with 144,900,000 and 144,400,000 lb. respectively. The rest, except the Calumet & Hecla with 84,116,000 lb., handle less than 50,000,000 lb. each.

The Copper Market in 1913.[2]—The year 1913 proved to be remarkable in several respects, and compared with the great revival of the market in 1912 it was somewhat disappointing. The average price paid for electrolytic copper at New York for the year was about 15 1/4 cents per pound, as compared with 16 3/8 cents for 1912. This decline was due to a number of causes: (1) The production of refined copper increased during the year, while the smelter production decreased; and, (2) domestic consumption decreased while the European demand was unusually large.

The year opened with electrolytic copper at 17 1/2 cents cash, at New York, but the market soon crumbled away. By the end of January electrolytic had declined to 16 cents, and by the end of February it was down to 14 1/2. During February the market worked into a more normal condition. American and European buyers having depleted their stocks, and being attracted into the market by the comparatively low price which had been established by that time, bought liberally and deliveries of copper assumed more normal proportions. In March, a fair amount of business was booked at around 15 cents. In April, the clearing of the political horizon in Europe and the accompanying relaxation in the tension of the money market which had prevailed there for some time, brought about an improvement in general business conditions, which found a pronounced reflection in the copper market. Early in May, when the political situation abroad became alarming, liquidation in the London Standard market ensued, which in turn scared off buyers of refined copper. Then, in the middle of the month, the political skies abroad were again brighter, large orders were placed, and as the American statistics for April showed a very heavy decrease in the visible supply, heavy purchases were made, and the prices advanced to 15 7/8 cents, delivered at buyers' works, usual terms.

[1] The Boston News Bureau, through *Eng. Min. Jour.*, Feb. 7, 1914.
[2] Taken in part from the *Eng. Min. Jour.*, Jan. 10, 1914.

During May and June the financial stringency in Europe, the aftermath of the Balkan war, affected sentiment over there and kept buyers out of the market, and the Standard market in London and the electrolytic market at New York declined steadily. By July 1 Standard had gone down to about £64 and electrolytic had gone back to 14 1/4 cents, but even at these prices the market remained dull and weak. American consumers remained completely apathetic at 14 cents, but when they found that the European consumers were taking the copper freely at that level, they also came into the market and prices advanced sharply, with large transactions, moving up to 15 cents, delivered. As the result of the buying movement, the producers were now comfortably booked for August and September, and in view of the small stocks and the strike which had broken out at Lake Superior, the position of the metal was an exceedingly strong one, and in August a large business was done at higher prices. From Sept. 3 to Sept. 8, there was an almost perpendicular rise, and transactions amounted to many millions of pounds. By Sept. 10, the market had reached 16 3/4 cents.

During October the market relapsed into dullness. There was also a decided falling off in European consumption. These conditions continued and the market remained quiet until about the middle of December, when prices again crumbled away. By the time 14 1/4 cents, delivered, was reached, European consumers had completely exhausted their supplies and were forced into the market, and there was also a decided improvement in business sentiment in the United States, due to the passing of the Currency Bill. American consumers had also been feeding on their previous purchases, and their stocks being entirely depleted, they too came into the market. In consequence, the second half of December witnessed large transactions, and during the last few days of the year a large business was done at 14 7/8 cents, delivered buyers' works, and the copper market closed active and strong at that figure.

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK. (*a*)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1904.	12.410	12.063	12.299	12.923	12.758	12.269	12.380	12.343	12.495	12.993	14.284	14.661	12.823
1905.	15.008	15.008	15.125	14.920	14.627	14.673	14.888	15.664	15.965	16.279	16.599	18.328	15.590
1906.	18.310	17.869	18.361	18.375	18.457	18.442	18.190	18.380	19.033	21.203	21.833	22.885	19.278
1907.	24.404	24.869	25.065	24.224	24.048	22.665	21.130	18.356	15.565	13.169	13.391	13.163	20.004
1908.	13.726	12.905	12.704	12.743	12.598	12.675	12.702	13.462	13.388	13.354	14.130	14.111	13.208
1909.	13.893	12.949	12.387	12.563	12.893	13.214	12.880	13.007	12.870	12.700	13.125	13.298	12.982
1910.	13.620	13.332	13.255	12.733	12.550	12.404	12.215	12.490	12.379	12.553	12.742	12.581	12.738
1911.	12.295	12.256	12.139	12.019	11.989	12.385	12.463	13.405	12.201	12.189	12.616	13.552	12.376
1912.	14.094	14.084	14.698	15.741	16.031	17.234	17.190	17.498	17.508	17.314	17.326	17.376	16.341
1913.	16.488	14.971	14.713	15.291	15.436	14.672	14.192	15.400	16.328	16.337	15.182	14.224	.....

(*a*) From *Eng. Min. Jour.*

AVERAGE PRICE OF STANDARD COPPER (G. M. B.'s) IN LONDON. (a)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1903....	53.52	57.34	63.85	61.72	61.73	57.30	56.64	58.44	56.82	55.60	56.30	56.36	57.97
1904....	57.500	56.500	57.321	58.247	57.321	56.398	57.256	59.952	57.645	60.012	65.085	66.375	58.884
1905....	68.262	67.963	68.174	67.017	64.875	65.881	66.887	69.830	69.667	71.406	74.727	78.993	69.465
1906....	78.869	78.147	81.111	84.793	84.867	83.994	81.167	83.864	87.831	97.269	100.270	105.226	87.282
1907....	106.739	107.356	106.594	98.625	102.375	97.272	95.016	79.679	68.375	60.717	61.226	60.113	87.007
1908....	62.386	58.786	58.761	58.331	57.387	57.842	57.989	60.500	60.338	60.139	63.417	62.943	59.902
1909....	61.198	57.688	56.231	57.363	59.338	59.627	58.556	59.393	59.021	57.551	58.917	59.906	58.732
1910....	60.923	59.388	59.214	57.238	56.313	55.310	54.194	55.733	55.207	56.722	57.634	56.069	57.054
1911....	55.604	54.970	54.704	54.035	54.313	56.368	56.670	56.264	55.253	55.176	57.253	62.063	55.973
1912....	62.760	62.893	65.884	70.294	72.352	78.259	76.636	78.670	78.762	76.389	76.890	75.516	73.942
1913....	71.741	65.519	65.329	68.111	68.807	67.140	64.166	69.200	73.125	73.383	68.275	65.223	.....

AVERAGE PRICE OF LAKE COPPER PER POUND IN NEW YORK. (a)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1903.	12.361	12.901	14.752	14.642	14.618	14.212	13.341	13.159	13.345	12.954	12.813	12.084	13.417
1904.	12.533	12.245	12.551	13.120	13.000	12.399	12.505	12.468	12.620	13.118	14.456	14.849	12.990
1905.	15.128	15.136	15.250	15.045	14.820	14.813	15.005	15.725	15.978	16.332	16.758	18.398	15.699
1906.	18.419	18.116	18.641	18.688	18.724	18.719	18.585	18.706	19.328	21.722	22.398	23.350	19.616
1907.	24.825	25.236	25.560	25.260	25.072	24.140	21.923	19.255	16.047	13.551	13.870	13.393	20.661
1908.	13.901	13.098	12.875	12.928	12.788	12.877	12.933	13.639	13.600	13.646	14.386	14.411	13.424
1909.	14.280	13.295	12.826	12.938	13.238	13.548	13.363	13.296	13.210	13.030	13.354	13.647	13.335
1910.	13.870	13.719	13.586	13.091	12.885	12.798	12.570	12.715	12.668	12.788	12.914	12.863	13.039
1911.	12.680	12.611	12.447	12.275	12.214	12.611	12.720	12.634	12.508	12.370	12.769	13.768	12.634
1912.	14.337	14.329	14.868	15.930	16.245	17.443	17.353	17.644	17.698	17.661	17.617	17.600	16.560
1913.	16.767	15.253	14.930	15.565	15.738	14.871	14.563	15.904	16.799	16.913	16.022	14.904	.....

(a) *Eng. Min. Jour.*

AVERAGE MONTHLY PRICES OF COPPER MANUFACTURES. (a)
(In cents per pound.)

	1912.		1913.	
	Copper Wire.	Sheet Copper.	Copper Wire.	Sheet Copper.
Jan.	15.75	19.50	19.09	23.50
Feb.	15.25	19.50	16.38	22.50
Mar.	16.03	20.30	16.39	21.50
Apr.	17.06	21.50	16.50	21.50
May.	17.30	21.63	16.50	21.50
June.	18.68	22.50	16.18	21.10
July.	19.13	22.50	15.88	20.50
Aug.	19.13	22.75	16.60	21.50
Sept.	19.13	23.50	17.84	22.50
Oct.	19.13	23.50	17.75	22.50
Nov.	19.13	23.50	17.28	21.15
Dec.	19.13	23.50	15.79	20.50
Year.	17.96	22.02	16.85	21.69

(a) *Eng. Min. Jour.*

Price.[1]—Nearly all of the big copper-producing companies have now made their reports for 1913, and it is possible to compare the prices that they received for the sale of their product. It is fruitless to consider the reports of the Lake Superior companies, inasmuch as for them the

[1] The Price for Copper in 1913, Editorial, *Eng. Min. Jour.*, May 15, 1914.

year was so interrupted by the strike. During the last 5 months of 1913 they produced but relatively little copper, and their sales were chiefly of the metal that they had on hand and were decidedly scattered and irregular in character.

Anyway, it is the electrolytic copper which determines the market, and the producers of electrolytic copper now report so generally that it is possible to obtain a broad view of their returns. Especially is that so since in 1913 many of them began to report their price received, reduced to the basis of New York, net cash. In speaking roughly of the price for copper, persons in the trade talk commonly about the gross price, which includes the delivery charges (freight, etc.) to the consumers' works, and also other allowances. In 1913 the delivery charges as reported by the Chino, Ray and Utah companies came to 0.17 cents per pound. Miami reported 0.20 cents per pound "for selling expenses, freight and export insurance." Phelps, Dodge & Co. reports the net cash price, New York, and Nevada Consolidated reports the net price, f. o. b. Atlantic seaboard.

The figures reported by 10 large companies in 1912 and 11 in 1913 are given in the accompanying tables. Apparently the United States company realized the highest average in 1913, but we surmise that its figure includes the delivery charges. If that surmise be correct, Phelps, Dodge & Co. realized the highest average, the figure reported by it being the net cash price, New York basis. The Greene-Cananea and North Butte copper is sold by the United Metals Selling Co., and these are the only products sold by that agency that are publicly reported. The Anaconda's reports give no intimation of the price realized for its large output.

The copper reported by these companies in 1913 amounted to 658,533,402 lb., selling for $100,248,273, or an average of 15.222 cents per pound. The quotational average for 1913, as reported by the *Engineering and Mining Journal* was 15.269 cents per pound. In 1912 the copper companies, generally speaking, fell far short of attaining the quotational average; in 1913, they came much nearer to it.

In 1912 the price for copper rose steadily during the first half of the year and remained at a high level during the second half. This was the famous period of pegged prices, during which the largest producers sold the less of their copper. The great break did not come until December. Much depended therefore upon the time when the copper was sold. Certain of the smaller companies sold largely at cut prices, which looked small at the time but looked big later on, and realized high averages for the year. Other companies made their larger sales when the market was low. The result was a range of over 1 cent per pound in the averages actually realized.

In 1913 there were several ups and downs, while the total range of price was confined within relatively narrow limits, the highest monthly average having been about 16½ cents and the lowest about 14¼ cents. In brief, 1913 was quite a normal year. This shows also in the averages reported by the companies, most of which fall between the limits of 15.08 cents and 15.37 cents.

COPPER PROCEEDS IN 1912.

Company.	Lb.	Value.	Average.
Chino	27,776,088	$4,344,262	(b) 15.640
East Butte	14,709,460	2,455,303	(b) 16.692
Greene Cananea	48,157,847	7,714,405	(b) 16.019
Miami	32,477,923	5,343,917	(a) 16.454
Nevada Cons	63,063,261	10,076,872	(c) 15.979
North Butte	26,480,123	4,334,531	(b) 16.369
P. D. & Co	192,297,374	29,825,323	(a) 15.51
Ray	34,674,275	5,467,297	(b) 15.762
United States	21,152,620	3,434,551	(b) 16.237
Utah	91,366,337	14,471,576	(b) 15.839
Total	552,155,308	$87,468,037	15.841
Quotational average reported by *Eng. & Min. Journal*			16.341

COPPER PROCEEDS IN 1913.

Company.	Lb.	Value.	Average.
Chino	50,511,661	$7,739,398	(a) 15.322
East Butte	14,401,108	2,277,591	(a) 15.086
Greene Cananea	44,480,514	6,716,558	(b) 15.10
Miami	33,134,334	4,983,404	(a) 15.04
Nevada Cons	64,972,829	9,667,307	(c) 14.879
North Butte	27,685,400	4,176,619	(b) 15.086
P. D. & Co	201,489,796	30,968,982	(a) 15.37
Ray	52,341,029	7,955,836	(a) 15.20
United States	20,239,973	3,123,028	(b) 15.43
United Verde	35,333,924	5,358,036	(d) 15.164
Utah	113,942,834	17,281,710	(a) 15.167
Total	658,553,402	$100,248,488	15.222
Quotational average reported by *Eng. & Min. Journal*			15.269

(a) Net cash, New York; (b) Whether gross or net price not stated. (c) Price f. o. b. Atlantic seaboard. (d) As given by the Boston News Bureau.

The quotational average for 1913 was 1.09 cents lower than in 1912, but considering what was actually realized by the producers last year was not relatively so bad a one, their actual proceeds having been only about 5/8 cent per pound less than in 1912.

Copper Mining in the United States

Alaska.[1]—Eight copper mines were operated on a productive basis in 1913. It is estimated that in 1913 about 42,000 tons of ore were hoisted and yielded about 19,700,000 lb. of copper, valued at about $3,014,000, $160,000 worth of gold, and $150,000 worth of silver. The decrease of over 9,000,000 lb. in copper production compared with the previous year is due to the fact that the Kennecott-Bonanza which is the largest producer in the territory was closed down on account of accidents, during about one-third of the year.

[1] Mining in Alaska in 1913. Advance statement of U. S. Geol. Surv.

The Jumbo and Rush and Brown mines in the Ketchikan district were operated on a shipping basis, and some developments were made on other copper properties, notably at the mines of the Northland Development Co., on the west side of Prince of Wales Island.

There was no great activity in the Kotsina-Chitina copper belt during 1913. The Kennecott-Bonanza continues to be the only productive mine and its operation was much hampered by the destruction of tramway and compressor plant by a snowslide and fire, causing a shut-down for about 4 months. Considerable work was also done on the nearby Jumbo claim, and a tramway is in course of construction on the Mother Lode property. A wagon road has been built from the lower end of this tram to the railroad. Some work was also done on the Dan creek property, near the eastern end of the copper belt. There was comparatively little mining at the western end of the field. Developments are reported on the Hubbard and Elliot property on Nugget creek, and on the Berg claim, the latter located on the east side of the Kuskulina river. Some work was also done by the Great Northern Development Co., which shipped some ore from its property during the winter of 1912–1913.

On Prince William Sound the Ellamar and Beatson copper mines were operated to full capacity in 1913. Shipments were also made from the properties of the Fidalgo Mining Co. and from the Fidalgo-Alaska Copper Co. The Dickey Copper Co. opened the Mason and Gleason Claim on Fidalgo Bay, and mined some ore which will be sledded to the beach during the winter. Developments were continued by the Three Man Mining Co. and the Land Lock Bay Copper Co. Work was suspended during the summer at the Midas Copper mine, near Valdez, but was resumed by a new company which acquired the property in the fall. Work was continued in a small way on the copper properties of the Iliamna region.

Arizona.—During 1913 Arizona exceeded the high rate of production which characterized the year 1912 by more than 12 per cent. and still holds first place among the copper-producing states. The mine production[1] for the year was about 414,593,000 lb., and the smelter output[2] 401,223,786 lb., as compared with 365,038,649 lb., and 357,952,962 lb., for 1912. The total value of the mine output for 1913 has been estimated to be about $71,000,000 which is only about $3,500,000 more than the value of the output of 1912, owing to the lower price of copper during 1913.

The erection of new smelting works by the Arizona Copper Co. and the United Verde Co. were the most important steps toward the development of the copper interests of Arizona during the past year.

[1] Preliminary Statement, U. S. Geological Survey.
[2] *Eng. Min. Jour.*, Jan. 10, 1914.

The new smelter of the Calumet and Arizona Co. at Douglas, adjacent to the site of the old one, has been designed for both cupola and reverberatory work, and is larger. At present the monthly output of the smelter exceeds 5,000,000 lb. of copper.

During the year ending Sept. 30, 1913, The Arizona Copper Co., Clifton, Ariz., according to its annual report, operated at a profit of $1,428,780. The final figures show a production of 34,226,000 lb. of copper, a decrease of about 4,000,000 lb. as compared with the previous year. This was due to the lower grade of the ore mined, and delay in getting the new smelting plant up to full capacity. The mine production was 936,903 dry tons of ore averaging 38.76 lb. of copper per ton. This is a decrease of 2.39 lb. per ton compared with the previous year. About 72 per cent. of the ore produced came from the Longfellow group, and 28 per cent. from the Metcalf group. About 95 per cent. of the ore was of concentrating quality, and the rest was direct smelting ore. The oxide concentrator treated 106,596 tons of ore, and 85,071 dry tons of its tailings were treated by the leaching plant. Of the total copper produced about 9.27 per cent. came from the oxidized ores. The sulphuric acid plant supplied 3352 tons of acid to the leacher. When the change is completed which is being made in the No. 6 concentrator where Hardinge conical mills are replacing the old Huntington mills, the plant will have a daily capacity of 3500 tons.

The Phelps, Dodge & Co. properties produced 155,665,712 lb. of copper from 1,978,892 tons of ore, during the year, and paid to the controlling company $9,110,000 in dividends.

The annual report of the Copper Queen Consolidated Mining Co., Douglas and Bisbee, Ariz., for 1913, shows metal production from 1,034,357 tons of ore treated as follows:

PRODUCTION OF REDUCTION WORKS.

	Tons Treated.	Pounds Copper.	Ounces Gold.	Ounces Silver.
Copper Queen Ore and Precipitates	692,897	82,355,137	14,855	608,662
Copper Queen old dump slag	97,165	3,039,691	.....	200
Copper Queen lease ores	21,287	3,250,490	358	17,642
Moctezuma ore and concentrates	140,134	36,598,432	1,343	526,570
All other ores	82,874	8,167,132	14,585	717,088
Total	1,034,357	133,410,582	31,141	1,870,162
Ore Shipped:				
To El Paso[1]	15,573	290,789	896	203,214
To Globe	18,136	334,335	507	7,204

The Copper Queen mines and old dumps produced 867,481 tons of ore, slag, precipitates, etc., containing 97,181,725 lb. copper, 16,213 oz. gold, 919,138 oz. silver, and 5,701,628 lb. of lead. Compared with 1912 the ore mined showed an increase of 81,113 tons and 8,900,817 lb.

[1] The ore shipped to El Paso also yielded 5,701,628 lb. lead.

of copper. The reduction works purchased 1,041,453 tons of copper-bearing material, from which 141,551,247 lb. of copper was produced.

Extensive development work was carried on by the company during the year with satisfactory showing of new ore. The most interesting strike was the exposure of ore on the Wade Hampton and White Tail Deer, two claims long neglected, but members of large groups owned by the Copper Queen to the west of Bisbee. The estimate of ore reserves shows a total of 2,567,928 tons of average grade, and 211,199 tons of lean sulphide in the Limestone mine.

The Copper Queen Co. finished the erection of a third reverberatory which will relieve the cupola furnace of much fine ore and enable them to run with a lower blast, less fuel, and the production of less flue dust. During the year an experimental plant has been running on a small working scale, the operations being principally for devising the most economical method of extracting copper from extremely fine tailings from the slime tables of the company's mills. It is in these that the heaviest waste of concentration occurs.

The Detroit Copper Mining Co. of Ariz. mined during the year a total of 533,563 tons of ore of all classes, averaging 2.89 per cent. copper, from all the company's mines. Of this, 518,718 tons was concentrating ore. A Nordberg compressor was installed to operate a larger number of drills, and new change houses and other improvements were built. On the outside mines development work was continued on the Esperanza, Sante Rosa, Wattle, Fairbanks, and Summit claims, while exploration was started at the Gem, Summit No. 2, Colorado and Antietam properties. The installation of new hoisting plants at practically all these properties, and the enlargement of plants at properties under development, meant very high outlays during the year. Power lines were built to some of these outlying camps.

The blast-furnace treated 141,094 tons of mixed products, from which 22,255,130 lb. of bullion was produced. The concentrating plant treated 517,518 tons of ore averaging 2.785 per cent. copper, and produced 66,928 tons of concentrates with a copper content of 15.834 per cent. A total of 1510 men were employed, 946 working at the mines. The net earnings of the company for 1913 were $1,112,870, of which $780,000 was paid in dividends to the shareholders.[1]

The Detroit Copper Co. has extended its ownership over the properties of the Standard Copper Co., and the New England & Clifton Co., but as yet no new ore-bodies of any significant value have been developed in these mines. The company realizes that it must rely on low-grade ores for the future and it is making provisions for handling them economically.[2]

[1] Annual Report, Phelps Dodge & Co., for 1913.
[2] James Douglas, Copper Metallurgy in Arizona in 1913. *Eng. Min. Jour.*, Jan. 10, 1913.

The Superior & Boston Copper Co., Globe, Ariz., has done considerable development work during the year, and has mined 15,485 tons of ore. It is stated that a new ore-body, first encountered about a year ago, on the eighth level, has been developed by raises between the eighth and sixth levels and laterally on the levels and in stopes. This has made it possible to resume ore shipments.

The Shattuck Arizona Copper Co. in 1913 produced 13,219,756 lb. of copper, 236,000 oz. silver, and 2033 oz. gold. The ore mined was 89,857 dry tons, and ore shipped, 89,317, while 89,343 tons were smelted. The total receipts of the company for a 17-month period ending Dec. 31, 1913, was $2,562,668. The operating expenses for the same period was $1,411,788, and the net profit was $1,115,504. Dividends to the amount of $525,000 were paid, leaving a net surplus after deducting $35,376 for depreciation, of $590,504.

During the period covered by the report 20,147 ft. of development work was done, and improvements and construction to the amount of $32,138 were made. The company ores are smelted by the Calumet & Arizona Mining Co., and the product is sold by Adolph Lewisohn & Sons.

The Arizona Commercial Mining Co., operating at Copperhill, near Globe, made a small shipment of 494 tons of ore averaging 3.58 per cent. copper. Considerable development work has been carried on with fair results.

In the annual report of the Inspiration Copper Co. the General Manager, Mr. C. E. Mills, states that the 600-ton flotation plant which has been in operation for over 3 months has yielded a concentrate more free from silica than was expected from the results in the 50-ton plant. The figures bearing on the percentage recovery are not given in the report but they are known to be high, and the management is well pleased with results. The present design of the mill involves the preliminary concentration on tables. The total development work done so far amounts to 110,609 ft., and the total tonnage of ore developed is as follows: 45,000,000 tons of sulphide ore averaging 2 per cent. copper; 28,322,000 tons of sulphide ore carrying an average of 1.26 per cent. copper; 12,500,000 tons of oxidized material carrying 1.34 per cent. copper; and 2,876,000 tons of mixed oxides and sulphides averaging 1.24 per cent. copper. A branch railroad is to be constructed, a steam plant installed, and more land is to be acquired by this company.

The annual report of the Miami Copper Co. of Arizona shows that from 1,058,784 tons of ore mined, containing an average of 2.3 per cent. copper, there was produced 45,410 tons of concentrates containing 38.9 per cent. copper, or 34,597,568 lb. of copper. From these concentrates, the net smelter returns of refined copper amounted to 32,867,666 lb.

The concentrate production in 1912 was 34,560,665 lb. of copper and the net smelter reduction was 32,832,609 lb. A comparison with these figures shows that the production for 1913 was about the same as that for 1912. The causes preventing an increase in production for the past year have been overcome and the mine now averages at least 33,000 tons of ore per day.

The cost of production during 1913 for mining, milling and general expenses was $2.4651 per ton of ore or $0.07907 per pound of copper.

(By J. Parke Channing).—During the year about 37,000 ft. of development work was done, a large part of which was in the Captain ore-body. This ore-body has an extreme height of 350 ft. above the 420-ft. haulage level and it is planned to mine it in two lifts, probably using 15-ft. stopes with 10-ft. pillars. The development work for the 420-ft. level has shown ore to exist 200 ft. east of the boundaries as determined in this portion of the property by churn drillings. The ore developed for the year will probably equal that extracted after allowing for loss, thus putting the reserves of sulphide ore at approximately 20,800,000 tons of 2.48 per cent. copper ore, and in addition, there has been developed 6,000,000 tons of 2 per cent. ore, of which half the copper is present in the form of sulphide, the other half being oxide. No change is made in the 17,000,200 tons of low-grade material, which was reported last year at 1.21 per cent. copper. A large portion of the ore mined during 1913 consisted of slicing the mine ore-body east of No. 2 shaft. This is nearly all sliced down to a 370-ft. level. The installation of Hardinge mills was completed in January. Three Evans-Waddell Chilean mills are still running in Section Five. These mills have about the same capacity as the 8-ft. Hardinge mills and the maintenance is about the same. Considerable experimental work on Hardinge mill runnings was done during 1913.

The Calumet and Arizona produced 52,897,383 lb. of copper during 1913, as shown by the annual report of the Calumet and Arizona, and its subsidiary, the Superior and Pittsburg. The production in 1912 was 53,108,628 lb. so that the output for 1913 shows a decrease of about half a million pounds. The combined profit for the year was $4,074,637 which resulted from the above production of copper, together with 880,914 oz. of silver and 18,988 oz. of gold. The average cost of the copper was 7.65 cents per pound. Dividends aggregating $3,059,208 were paid during the year by the Calumet and Arizona. The statement of income and expenditures of the Calumet and Arizona shows a net income of $3,001,150 for the year. The company has purchased 688,623 shares of the New Cornelia and has options on additional shares that will make its total holdings equal to 76.75 per cent. of the stock. It is estimated

that this property has 40,258,000 tons of 1.51 per cent. copper ore in reserve.

The Calumet and Arizona now owns 1,402,563 shares of the Superior and Pittsburg, and it is expected that the remaining outstanding stock will be turned in for exchange at an early date. Experiments have been made in the sulphide ores for concentration by oil flotation and results show that a high saving can be made. The total expenditures for the new smeltery which this company has erected were $2,218,318, which is 13.86 per cent. in excess of the first estimate.

In 1913, the Ray Consolidated Copper Co. milled 2,365,296 tons of ore yielding 53,745,937 lb. of copper. These figures compare with 1,565,875 tons of ore handled during 1912, from which there was obtained 35,851,496 lb. of copper. During the year's operations, there was mined including the small tonnage of ore shipped direct to the smelter, a total of 2,366,007 tons, averaging 1.72 per cent. copper. The total tonnage mined from the beginning of operations up to the end of the year 1913 was 4,613,402 tons and the total developed tonnage still remaining is 78,380,966 tons. As stated in the last annual report, however, the limits of all the ore-bodies have been by no means defined, either laterally or as to depth, and this is particularly true in the western section where at several points drilling operations for development were discontinued in ore. Increased ore reserves much greater than the quantity of ore that has been mined since the beginning will quite certainly be developed with the moderate amount of additional exploratory drilling. At the end of 1912, it was estimated that there was about 2,500,000 tons of ore broken in stopes and in reserve areas, in which stoping had been completed. At the close of the year, it is estimated that in all parts of the mine there is about 5,000,000 tons of broken ore. Of the total tonnage produced for the year, 63.4 per cent. was mined from the No. 1 shaft territory. The area served by the No. 2 shaft produced 33.4 per cent. The No. 3 shaft, serving the higher grade ore-body, produced only 3.3 per cent.

As in the previous year, most of the tonnage mined in the No. 1 area came from a comparatively low-grade body of ore, which on account of its location, it was necessary to mine out before the deeper laying and better grade ores in that section could be attacked. There still remains a very large reserve tonnage of this lower grade material, which will be drawn upon during the coming year. The cost of mining ore from all sources for the year was 73.23 cents per ton as compared with 77.55 cents per ton for the year 1912. These costs include all fixed and general charges, as well as the cost of operating the coarse crushing plant at the mine and loading the crushed ore into cars for shipment to the mill. The total amount of ore treated for the year was 2,365,296 tons cor-

responding to a daily average of 6480 tons as compared with 1,565,875 tons for the year 1912. The increase of tonnage for the year 1913 over that for 1912 was accordingly about 51 per cent. The average copper content of the ore treated for 1913 was 1.719 per cent. as compared with 1.677 per cent. for 1912. The average recovery for the year based on the total copper contained in concentrates produced was 66.09 per cent., corresponding to 22.723 lb. of copper per ton of ore, as compared with 22.9 lb. for the previous year. The recoveries for the year were affected adversely by a considerable amount of oxidized ores, coming at times from the upper levels, and also by the irregular operations of the mill during the last half of the year when improvements were in progress. These improvements have raised the recoveries to a point exceeding 68 per cent. and when completed the savings will be even more.

The cost of milling for the year is 51.93 cents per ton as compared with 46.88 cents per ton for the previous year. This increase is due solely to the intermittent operations of the plant during the latter half of the year.

The average cost of net copper produced after making allowances for smelting and refining deductions, was 9.7836 cents per pound as compared with 9.281 cents per pound for the previous year. The mine is now fully and finally equipped and its equipment is operating as efficiently as could be desired. Underground development has reached a state where the excess expenditures for this purpose over and above those regularly absorbed into operating costs are decreasing rapidly. The outlook for the year 1914 is that the percentage of increase in copper production will be almost as great over the production of 1913 as was the increase of that year over the production of 1912. Such being the case, in view of the actual and physical and operating conditions prevailing, there will undoubtedly be a marked decrease in the cost of producing copper during the coming year.[1]

The Copper Reef, southwest of San Carlos, displaying one of the world's most extensive mineralized surface areas, was the scene of considerable development during 1913, an electric furnace having been tested at Globe, with the Copper Reef ores. A program of active development in this region has been planned for in the near future.

The Old Dominion Copper Mining and Smelting Co. at Globe, Arizona, produced in 1913 a total of 30,810,000 lb. of copper as compared with its production of 27,000,000 lb. in 1912. This was done in spite of being handicapped during the latter part of the year by a complete change of hoisting methods and equipment, that retarded ore hoist-

[1] D. C. Jackling, Report of the Ray Consolidated Copper Co., Arizona. *Min. Eng. World*, May 2, 1914.

ing to a considerable extent. Under favorable conditions the company is now prepared to produce copper at the rate of 3,000,000 lb. monthly during the coming year.[1]

California.[2]—The production of copper in California in 1913 shows an increase of nearly a million pounds over the record for 1912, the figures for the two years being 32,492,256 lb. and 31,516,471 lb. respectively. The chief producer was the Mammoth mine, in Shasta County, and the Calaveras Copper Co. comes next in importance. Notwithstanding the opposition to the Mammoth smelter on the part of the farmers of Shasta County, the smelter was able to continue operations throughout the year.

The Bully Hill mine, in Shasta County, is still experimenting with a leaching process for its zinc ores, and produced no copper in 1913. The Balaklala mine in the same county has been shipping small lots of ore to another smeltery, while its own plant has remained idle. This company is now considering the shipment of its ores by rail to San Francisco and thence to the smeltery at Tacoma, Washington. Some ore will also be shipped to the Mason Valley smelter in Nevada.

The Mountain Copper Co., of Keswick, Shasta Co., ships the ores from its mines by rail to its smeltery on the shores of San Francisco bay. In the old Iron Mountain mine of this company extensive bodies of low-grade copper ore have been discovered, and plans have been made for large concentrating plant to be erected at the mine. The concentrates will be shipped to the company's smelter.

Colorado.—The output of copper from 599,584 tons of ore smelted at the Globe, Pueblo, Arkansas Valley, and Durango plants of the American Smelting and Refining Co. and from ores shipped to this company's plants outside of Colorado was 6,852,992 lb. The total production of the state during 1913 was 9,052,104 lb. as compared with 7,963,520 lb. in 1912.[3] The main production is derived from the treatment of ores containing only a small amount of copper. The only producing properties which can be properly classed as copper mines are in the San Juan district, at notably the Indiana and the Congress at Red Mountain.

Idaho.—The report of the State Inspector of Mines, Mr. Robert N. Bell, for 1913 gives the following production of copper in Idaho for the last 5 years:

1909	7,759,886 lb.
1910	5,837,639 lb.
1911	3,962,060 lb.
1912	7,392,280 lb.
1913	8,627,242 lb.

[1] *Min. Eng. World*, January 24, 1914.
[2] Production figures from U. S. Geological Survey, Advance Statement. Mining news from *Salt Lake Min. Rev.*, Jan. 15, 1914.
[3] Advance Statement, U. S. Geological Survey.

The principal producing mines are the Snowstorm, in Shoshone County; the White Knob, in Custer County, and the Lost Packer, also in Custer County. The Snowstorm mine has been a producer for the past 10 years, and furnished most of the state's copper output in 1913. The ore consists of copper carbonate disseminated in the Revette quartzite of pre-Cambrian age. In places the carbonate ore gives place to sulphides, principally chalcopyrite, bornite, and chalcocite. A fault at the No. 3 tunnel has cut off the ore, and its continuation has not yet been discovered. The future of this property depends upon the recovery of the lost ore-body at this fault, as the present ore reserve is very low. Along the strike of the vein on which the Snowstorm is located are a number of promising prospects among which are the Snow Shoe and the National. On this latter property a 4800 ft. cross-cut tunnel has revealed the vein with a fairly uniform width of 60 ft. and carrying 2 to 3 per cent. copper, 6 to 7 oz. silver and 25 cents gold per ton, at a depth of 1700 ft. from the crest of the vein. After thorough testing of this ore a mill of 500 tons capacity has been designed and built, which it is thought will give 85 to 90 per cent. extraction of the valuable minerals which consist of chalcopyrite, bornite and chalcocite.

The operations of the Empire Copper Co. at Mackay, Custer County, made the second largest output of copper ore in the State. Monthly shipments of from 55 to 60 car loads of 50-ton capacity, were made to the smelters in Salt Lake Valley. The average copper content was about 6 per cent., with gold and silver values of $5 per ton. This company's property is extensive in area, and present development work promises to result in proving a reserve of copper sulphide ore that will greatly increase the present capacity of the mine.

At Loon Creek, Custer County, the Lost Packer mine has been developed on a narrow vein of chalcopyrite which has made a total yield of something like $700,000 worth of rich gold-bearing matte from the operation of a 100-ton hot-blast pyritic smelter, owned by the company. During the last summer a 30 days' run resulted in the production of 360 tons of a 50 per cent. matte carrying 10 oz. of gold per ton. From the sale of this matte $25,000 was paid in dividends to the stockholders.

The lack of railroad facilities has so far proved the principal drawback to the development of the many copper properties of Idaho.

Michigan (By Carl L. C. Fitchel[1]).—The year 1913 will long be remembered in the annals of the Lake Superior copper district. The first time in the history of the district, a period of nearly 50 years, a general strike was called by the Western Federation of Miners. This

[1] *Eng. and Min. Jour.*, Jan. 10, 1914.

organization has looked with longing eyes upon the copper district of Michigan for a long time and its emissaries had been quietly working among the men for a number of years.

The agitation and discontent aroused by these paid organizers was felt for the past 2 years and resulted in a number of men leaving the district, causing a labor shortage. New men came in, materially aiding the Federation in its campaign for membership.

On July 14, demands were made by the several locals in the district upon the various mining companies for a conference with their representatives for the purpose of discussing the possibilities of shortening the working day, raising the wages and making some changes in the working conditions, limiting the time of the conference to July 28, and demanding a reply to the request to be not later than July 21. The request was ignored by the companies and as a result a general strike was called on July 23 with the following demands: Recognition of the Western Federation of Miners; abolishment of the one-man drill or the working of two men on each drill; a minimum wage of $3 for trammers and $3.50 for miners; and an 8-hour working day.

The Department of Labor sent investigators into the district and offered its services in an attempt to bring about a settlement by arbitration, as also did Governor Ferris. The mining companies absolutely refused to deal with the Federation in any way, but stood ready at any and all times to meet with their men as employees to hear and adjust any legitimate grievance that might exist; taking the stand that the Federation was a detriment to good government, the future welfare of the men and the district as a whole.

The companies held off several weeks before bringing in outside men to fill the places of the men on strike and allowed all former employees who had not taken part in any violence or who were not openly antagonistic to the company to return to their former places, not to be discriminated against.

The Ojibway property was closed down during the summer, all work was abandoned and the mine was allowed to fill with water.

A change of management was made at the Mohawk and Wolverine properties. Theodore Dengler, formerly superintendent at the Atlantic mine, succeeded Fred Smith as agent and William Hartmann succeeded Willard Smith as superintendent of the Mohawk. Nos. 3 and 4 shafts of the Ahmeek started regular production, but no attempt was made to resume work at that branch after the strike. At the stamp mill, work was started on the erection of an addition to the mill. Contracts for all the machinery were closed, including a 2000-kw. low-pressure steam turbine to utilize the exhaust steam of the heads for the generation of

electrical energy. Mayflower and Old Colony did further diamond-drill work with results that correlated with the previous exploration.

The Calumet & Hecla took advantage of the temporary shut-down and the force at the mills was put on construction and repair work.

The Tamarack Mining Co. permanently closed down shortly after the strike was called, with the exception that the pumps were kept operating. No. 2 shaft of LaSalle was developing good ground in the lower levels, but no work has been done, other than pumping and keeping up repairs since July 24. An electrically driven pump was installed at the twelfth level of No. 2 shaft to handle all the mine water. Hancock began rock shipments to the Lake Milling, Smelting & Refining Co.'s plant, but has not attempted to resume operations. The Superior Co. shipped more rock to the mill for the past 6 weeks than it did during a like period before the strike.

DIVIDENDS PAID BY MICHIGAN MINES.

Mine.	1911.	1912.	1913.	Mine.	1911.	1912.	1913.
Calumet & Hecla	$2,400,000	4,200,000	$3,200,000	Quincy ...	$440,000	$550,000	$412,500
Copper Range Con.	1,357,104	2,100,000	1,082,700	Tamarack.	.....	.....	.....
Mohawk.....	175,000	350,000	500,000	Wolverine	540,000	550,000	300,000
Osceola.....	673,050	1,153,800	1,009,580	Totals....	$6,231,840	$9,069,259	$6,504,780

COPPER PRODUCTION IN MICHIGAN.
(Pounds of fine copper.)

Mines.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913. (a)
Adventure..	1,606,208	1,552,628	1,244,872	90,870	*Nil*	*Nil*	*Nil*	8,727,312	.....
Ahmeek.....	1,552,957	3,077,507	5,527,672	6,280,241	9,198,110	11,844,954	15,196,127	16,455,769	9,100,000
Allouez.....	1,167,957	3,486,900	2,934,116	3,047,051	4,031,532	4,655,702	4,780,494	5,525,455	4,091,129
Atlantic.....	4,049,731	1,439,082	*Nil*	*Nil*	43,483	19,018	*Nil*	*Nil*	.....
Baltic.....	14,384,684	14,397,557	16,704,868	17,724,854	17,817,836	17,549,762	15,370,449	13,373,961	8,686,000
Cal. & Hecla.	83,812,370	94,529,821	88,055,723	81,660,723	74,593,553	72,672,469	72,861,925	67,856,429	53,420,000
Centennial..	1,446,584	2,253,015	2,373,572	2,196,377	2,583,793	1,572,566	1,493,834	1,742,338	1,400,000
Champion...	15,707,427	16,954,986	16,489,436	17,786,763	18,005,071	19,224,124	15,639,426	17,225,508	11,448,000
Franklin	4,206,085	4,571,570	4,401,248	3,703,421	1,615,556	966,353	820,203	1,710,651	1,040,900
Isle Royale..	2,973,761	2,937,098	2,667,608	3,011,664	5,719,056	7,567,399	7,490,120	8,186,957	4,680,000
Mass.....	2,007,950	2,106,739	2,078,677	1,766,930	1,723,436	1,321,885	1,326,898	2,045,006	1,500,000
Michigan....	2,891,796	2,875,341	2,665,404	3,000,206	1,979,305	36,682	327,773	300,000	.....
Mohawk.....	9,387,614	9,352,252	10,107,266	10,295,881	11,248,474	11,412,066	12,091,056	11,995,598	5,369,000
Osceola.....	18,938,965	18,588,451	14,134,753	21,250,794	25,296,657	19,346,566	18,388,193	18,413,387	11,686,000
Phoenix.....	273,219	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	.....
Quincy.....	18,827,557	16,194,940	19,796,058	20,600,361	22,511,984	22,517,014	22,252,943	20,634,800	10,894,000
Superior.....	.....	.....	.....	21,244	1,789,315	3,181,041	3,236,233	3,921,974	3,078,000
Tamarack...	15,824,008	9,832,644	11,078,604	12,806,127	13,533,207	11,063,606	7,494,077	7,908,746	4,142,000
Trimountain	10,476,462	9,507,933	8,190,711	6,034,908	5,282,404	5,694,868	6,120,417	6,980,713	4,888,000
Winona.....	*Nil*	278,182	1,285,863	*Nil*	*Nil*	*Nil*	*Nil*	2,307,237	1,500,000
Wolverine...	9,464,418	9,548,123	9,273,351	9,555,233	9,971,482	10,469,253	9,630,639	9,408,960	1,550,000
Victoria.....	.....	.....	1,207,237	1,290,040	1,164,564	1,164,564	1,303,331	1,224,911	4,488,000
Others.....	.....	.....	100,000	.....	2,862,233	899,647	294,873		.....
Totals	218,999,753	224,071,103	220,317,041	222,123,688	230,971,051	223,179,539	216,119,011	225,945,712	.....

(a) Lake Superior Copper, R. H. Maurer, *Min. Eng. World*, Jan. 24, 1914.

The Copper Range Co. put in commission a low-pressure turbine at the Baltic mill, and installed several motor-driven Hardinge mills for re-

grinding purposes. The Lake Co. suspended all work and the property is entirely closed down and is being allowed to fill with water.

In the early part of 1913, exploratory work was being carried on by a number of companies besides the producing ones. Diamond drilling was done at the Adventure, Algomah, Keweenaw, Mayflower, Naumkeag, Old Colony and Ondagada. Development of lodes was continued at the Hancock, Houghton, Lauriaum Lake, Ojibway, St. Louis, White Pine and Wyandotte. During the strike many of these companies continued their work without interruption. Diamond drilling was not stopped by the strikers.

The Quincy Mining Co. installed a new hydraulic jig classifier devised by the company's stall and consulting metallurgists. The new apparatus, known as the Shield's Thielman jig classifier, is giving great satisfaction.

At several of the mines new rock houses were built and old ones improved. At the mills, especially those of the Calumet & Hecla subsidiary companies, there were many additions and improvements. At the Winona mill a new device known as the Lovett machine was found very successful in treating fine copper. It rolls the copper and makes its concentration easier.

During the year a company interested in power development did some preliminary work with the view to supplying the mines with power from the Sturgeon river.

The annual report of the Mass Cons. Mining Co. for 1913 shows that 95,434 tons of rock was hoisted, 78,250 tons of rock was stamped and 1,773,810 lb. of mineral was produced. The production of refined copper was 1,213,545 lb., which corresponds with 1.13 per cent. of mineral in the rock. The percentage of copper in mineral was 68.415 and the refined copper per ton of rock stamped amounts to 15.51 lb. The mine was closed down on July 23 on account of the general strike in the Lake copper district and remained idle during the rest of the year.

According to the annual report of the South Lake Mining Co., Houghton, Mich., its income amounted to $67,927 for 1913 from the sale of stock and interest receipts. The shaft started in 1912 to open up the ore-body which had been discovered by diamond drilling sunk to a depth of 537 ft. and plats were cut at the 300-, 400- and 500-ft. level. Three amygdaloid lodes showing good copper contents were cut by the shaft.

The annual report of the Tamarack Mining Co., Calumet, Mich., for the year ending December 31, 1913, shows that during the year 227,563 tons of ore was treated with an average yield of 18.3 lb. of copper per ton, making a total production of 4,168,743 lb. of copper. There were 230,677 tons of rock hoisted from the mine during 1913. The total depth

of the Tamarack shafts are as follows: Shaft No. 1, 3049 ft.; shaft No. 2, 4355 ft.; Shaft No. 3, 5253 ft.; Shaft No. 4, 4450 ft.; Shaft No. 5, 5308.5 ft. from the surface.

During 1913, the Ahmeek Mining Co., made a production of 9,220,874 lb. from 383,749 tons of rock stamped. During the year 385,450 tons of rock were hoisted, of which 1701 tons or about 4 per cent. was discarded as waste. Development work consisted of 104 ft. which compares with 1336 ft. in 1912. The Ahmeek, like other companies suffered from the general strike called in July 1913. The copper produced cost 13.30 cents per pound compared with 7.85 cents per pound in 1912. However, 3.33 cents of this increase was due to construction account, leaving increased cost over 1912 as 2.12 cents per lb. of copper.

Missouri.—During 1913 Missouri produced 12,300,600 tons of ore containing copper lead and zinc, as estimated by Mr. J. P. Dunlop of the U. S. Geological Survey. From this ore there was produced 576,204 lb. of copper in 1913, as compared with 440,725 lb. in 1912. The tonnage of ore treated was about 1,000,000 tons less than that for 1912, but the copper content was greater, the increase being 35,479 lb. The yield of copper was derived mainly from the dressing of lead concentrate from mines in southeastern Missouri.

Montana.—Montana ranks second among the states in copper production, and in 1913 the smelter output amounted to 285,719,918 lb. as compared with 308,770,826 lb. in 1912. Practically the whole output comes from the Butte district. In 1912 Butte produced about 308,000,000 lb., and in 1913 the output was 285,289,000 lb. of copper which is nearly the whole production of the state. Of the total, the Anaconda Copper Co. produced 270,301,644 lb., which is about 94 per cent. of the Butte production.

Anaconda (By B. B. Thayer).—Notwithstanding the feeling of pessimism concerning business conditions in general that existed throughout the country during 1913, and the skrinkage in business of every character which occurred during that period, the conditions in the Butte district were normal. All of the operating companies carried on work continuously, and there was new work undertaken which made itself felt materially.

The properties of the North Butte, Anaconda, East Butte, Alex Scott, Tuolumne, Pilot-Butte and Davis-Daly companies were operated upon the same scale as that of previous years. The operations of the Butte-Balaklava Mining Co. were somewhat restricted on account of litigation with the Anaconda Copper Mining Co., which controversy, however, was settled out of court during the latter part of the year.

The greatest amount of new work was done in the extreme eastern

section of the district. The Butte & Duluth Mining Co. and the Bullwhacker Mining Co. carried on operations continuously, and the officials of both companies have stated that the results obtained from their respective leaching plants were satisfactory.

The Rainbow Lode Development Co. was busy with development work for the entire period. The officials of the Butte & Superior Mining Co. expressed themselves as being well pleased with the results obtained in their concentrating department. The method of concentration, however, is at present involved in legal complications with the Minerals Separation Co.; but a regular output was maintained.

The copper ores extracted from the properties owned by W. A. Clark during 1913 were shipped for treatment at the Washoe smeltery, but his concentrator for the reduction of the zinc ores is rapidly nearing completion. It is thought that the complete output of zinc made by the Butte & Superior Mining Co. and the properties owned by W. A. Clark will be an important factor in the zinc production of this country.

The Anaconda Copper Mining Co. during the last few months of 1913 started some new work in the extreme western end of the Butte district, in a section known as the Burlington district, the ores of that section having been worked many years ago for silver.

A great deal of attention was given to experimentation with new processes by several of the companies, apparently with promising results. The processes, if worked out satisfactorily, will mean much to the Butte district in the future.

The output of copper from the Butte district during 1913 was less than that during 1912, due largely to extensive repairs which one of the large companies found it necessary to make, and also to the fact that on account of conditions the railroads at times were unable to deliver a sufficient quantity of ore to the several reduction works. The new companies have thus far not advanced sufficiently in their operations to make their output appreciable in the total output from the district.

The net mining profits of the Anaconda Copper Mining Co. for 1913 were $11,283,226. Smelter production for the year amounted to 270,301,644 lb. of copper, compared with 294,474,161 lb. in 1912; 10,321,296 oz. of silver, compared with 11,014,736; and 64,898 oz. of gold, compared with 61,314 oz. in 1912.

Receipts and disbursements in detail were as follows in 1913 compared with 1912:

The cost per pound of copper produced during the year 1913 was higher, due to the shut-down which has been mentioned, and also owing to the fact that the grade of ore treated was somewhat lower than that of the year previous.

There were 35.3 miles of development work, and a tonnage of ore in excess of the amount extracted was added to the ore reserves. Developments were satisfactory with but few exceptions, for while at several of the mines the result of some of the development work was disappointing, it was compensated for by very gratifying results in the greater portion of the territory explored, especially so in the case of the Original, Gagnon, Steward, Tramway, West Colusa, West Gray Rock, Anaconda, Badger State and Leonard properties. There was a marked improvement on the 2400-ft. level of the Anaconda mine. On the 3000-ft. level of the Original mine, a large vein carrying a good grade of ore was disclosed by the cross-cut. This level in the Original mine is at the greatest depth yet attained in the Butte district at which ore has been developed, with the exception of the High Ore mine.

Electric haulage, as practised in the Butte mines, has demonstrated the great economies to be effected by it over any other system of tramming. Preparations are being made to use electric haulage at all of the mines.

The mines of the company produced 4,644,201 tons of ore and 7243 tons of precipitates, or a total of 4,651,444 tons.

Reduction works treated for all companies 4,016,689 tons of ore at Anaconda, and 1,170,150 tons of ore at Great Falls. Of this 4,566,450 tons of ore from company mines, 619,864 tons of ore purchased from or treated for other companies, and 524 tons of precipitates and cleanings from the old works were treated; 241,983,323 lb. of copper, 8,719,132 oz. of silver, and 64,898 oz. of gold were produced by mines of the Anaconda Co.

North Butte.—This company had a very successful year in 1913. It produced an average daily output of 1300 tons, and its earnings for the year exceeded $1,600,000. The total product of copper was about 28,000,000 lb. The company confidently expects to increase the produce to 30,000,000 lb. next year. The company paid $2 per share in dividends, which was about 8 per cent. on the selling price of the mine, and $800,000 was added to the surplus in the treasury. The underground developments during 1913 were highly satisfactory. The future is very bright for the company, the reserves at the close of the year being larger than ever. The company has been engaged in sinking a 3-compartment shaft on the Granite Mountain claim, and intends to equip the works with the largest electric hoisting plant in this country. The engine will have a hoisting capacity of 300 tons per hour from the 2000-level and 200 tons per hour from the 4000-level, the skip holding 7 tons. It is expected to complete this equipment early in 1914, when the Speculator shaft will be closed and the company will hoist through the Granite Mountain shaft.

East Butte.—The East Butte Co. increased its output in 1913, and the mine is in satisfactory condition at the close of the year. Operations during the year were confined to the sixth, eighth and tenth levels. The copper output during the year was 14,289,476 lb. The main shaft was deepened 300 ft., to a depth of 1600 ft. during the year. Pumps were installed on the 1500-level, which was opened during 1913, and 800 ft. of work done in opening the level. In a short time the company expects to reach the first ore-bodies on this level.

Nettie.—The Anaconda Copper Co. added a new field to the established mining zone at Butte during the year by starting operations in the Nettie mine on the west side of the city. The company designs to sink the old shaft, which is down 450 ft. to a depth of 2000 ft., and mine the silver ores. The mine was a producer during the early epoch of the district. Many old silver properties in the district may be reopened if the mining of the Nettie turns out satisfactorily.

Tropic.—The Anaconda Copper Co., which owns this mine, has developed a large body of low-grade oxidized ore on the 700-level, where work was carried on during the year. The mine is in the newly opened oxidized zone east of Butte, where the Butte-Duluth and Bullwhacker properties are located. The shaft will be sunk to the 1500-level.

Davis-Daly.—The annual report of the Davis-Daly Copper Co., Butte, Mont., for the year ended June 30, 1913, shows a deficit of $97,343 on operations for the year. Receipts were as follows: Ore returns, $191,943; rentals, $1071; royalties, $2317; miscellaneous, $478; interest and discounts, $4272; total, $200,081. Operating charges amounted to $294,424 and consisted principally of development work. The report states that the Colorado is the principal mine of the Davis-Daly group. This mine has a vertical shaft 2030 ft. deep. The bottom level is 2000 ft. below the collar of the shaft. At the 1400-ft. level the mine is connected with the Moonlight mine of the Anaconda Co. During the year 6178 ft. of drifts and cross-cuts and raises were run and 46,923 cars of waste hoisted. There were also produced 33,153 dry tons of ore, averaging 64.94 lb. of copper and 5.96 oz. of silver per ton. The average cost of mining, including development, was $8.67, and receipts from the sale of ore averaged $5.73 per ton of ore. It is claimed that the mine was on a paying basis during May, June, July and August, 1913.

Nevada.—The copper production of Nevada for 1913 shows an increase of more than 1,500,000 lb. of copper, over the output of the previous year, the figures for the 2 years being 85,209,536 lb. and 83,413,900 lb. respectively.[1] As in previous year the principal producing districts are the Ely and the Yerington. An increase estimated at 2 per

[1] Advance Statement, U. S. Geol. Surv.

cent. in the mine production, from 86,477,494 lb. in 1912, to about 88,368,890 lb. in 1913, is due to a slight increase in the output of the Nevada Consolidated and Giroux mines from copper "porphyries" at Ely, and in a larger output of copper matte at the Thompson smelter from Mason Valley, Nevada Douglas and custom ores.[1]

Ely, in White Pine County, is the principal copper camp in the state, and during the year it made decided advances. The Nevada Con. Copper Co. duplicated its record of 1912 by paying its regular quarterly dividends of 37 1/2 cents a share, and an extra dividend of 50 cents at Christmas. More than 3,000,000 tons of ore was treated during the year, yielding 64,972,829 lb. of copper, and close to 3,000,000 tons of waste was removed. Considerable new ore was opened up which has greatly added to the ore reserves of the company.

An important consideration of the year was that of the Giroux and a number of other properties to form the Consolidated Copper Mines Co. The new Organization will build a new concentrator and a smelter. Considerable core drilling has been done on the property of the Nevada Con., and in excavating for tracks to the Liberty pit some high-grade porphyry ore was uncovered on the Ora claim. This necessitated the Giroux securing two steam shovels and starting work, and this ore-body has been found to be extensive enough to enable the company to keep up its contract to supply the Steptoe Valley smelter.

One of the greatest discoveries of the year was the uncovering of the ore in the Ora claim of the Con. Copper Mines Co. This ore-body is surrounded by the Nevada Consolidated, and will greatly add to the ore reserves of the company. The property consists of 107 patented claims. On these claims is located the two large pits, the Copper Flat and the Liberty pits. Considerable effort was made during the year to connect these pits. About 91 per cent. of the tonnage is taken from these pits, and the remaining 9 per cent. comes from the underground workings of the Veteran mine.[2]

The Nevada Douglas Copper Co., Mason, Nevada, operated its property at Ludwig and made a production of nearly 89,000 tons of ore that contained approximately 7,100,000 lb. of copper. During the latter part of the year an important strike was made in the Ludwig mine. A raise has been started in the ore and will be carried up upon the foot wall. This ore runs about 12 per cent. copper. At the Casting Copper mine regular shipments of 2 and 3 carloads of ore per day are going to the smelter at Thompson. This ore is broken and shipped without sorting, and runs about 7 1/2 per cent. copper.

[1] Nevada Metal Output, *Min. Sci. Pr.*, Jan. 10, 1914.
[2] *Min. Eng. World*, Jan. 24, 1914.

The Nevada Douglas made its first dividend payment during the year, and was one of the chief producers of the Yerington district. The company has kept development work well in advance of shipments and will soon erect a leaching plant that will allow the making of copper at a much lower price. The new leaching plant will treat the low-grade ore of the company, which has been held back waiting for the plant to be completed.

The Mason Valley Mines Co., Yerington, Nev., has continued the operation of its smelter at Thompson throughout the year with a production of 14,694,000 lb. of copper. On account of the Nev. Douglas shipping less ore, the output of the smelter was much less than it was in 1912. The Mason Valley property is believed to have blocked out 1,000,000 tons of ore averaging 3 per cent. copper during the last year. The tramway leading from the mine has been completed so that at times of ore shortage the mine can furnish the needed ore to maintain the smelter in operation.

The Yerington Malachite was one of the new shippers of the district to come to the front during the year. Working arrangements have been made with the Mason Valley for the development of the Malachite property through the Mason Valley No. 3 tunnel. Strong and large ore-bodies have been uncovered in the mine workings, and the indications seem to be that the Malachite will become one of the big mines of the district. Early in the year 2350 tons of ore was shipped, and later in the year occasional carload lots were sent to the smelter at Thompson.

The McConnel mine has been a steady shipper, producing 9200 tons of ore during the year. Recent development work has shown the presence of considerable amounts of sulphide ore of good shipping grade, but extensive development has not been done.

The Empire Nevada mine has produced about 2900 tons of ore during the year, the bulk of which came from lessees and was taken practically at the surface. It is now being vigorously prospected by churn drills, presumably by the Miami Copper Co., to which it is rumored to be bonded.[1]

New Mexico.—According to the advance figures issued by the U. S. Geological Survey the copper production of New Mexico for 1913 was 50,196,881 lb., as compared with 29,170,400 lb., in 1912. The greater part of this production comes from the operations of the Chino Copper Co., which is mining a low-grade deposit of "porphyry" ore at Santa Rita. This ore is concentrated at Hurley, where the 5000-ton mill was operated continuously throughout the year. According to the

[1] S. S. Arents, The Yerinton Copper District, *Salt Lake Min. Rev.*, Jan. 15, 1914.

report of the Chino Copper Co., 50,511,661 lb. of copper was produced from 1,942,700 tons of ore, during 1913, as compared with 28,684,208 lb. of copper from the 1,120,375 tons of ore treated in 1912. In the third quarter the company milled at Hurley 570,650 tons of ore yielding over 15,000,000 lb. of copper, or more than half the production of 1912. The extraction in the third quarter was about 67 per cent., and the mill averaged 5500 tons per day, which is its full capacity. The general conditions at the property continued favorable. The grade of the ore was slightly under 1.9 per cent., as compared with 2.077 per cent. for the previous year. The estimated ore reserve is 90,000,000 tons, averaging 1.8 per cent. copper.

The revenue for the year was $7,621,419, and the net operating profit was $3,190,293. Dividends amounting to $1,919,070 were distributed during the year.

The Phelps Dodge interests made preparations for the operation of their Burro Mountain Copper properties. The railroad extension from Whitewater to the Burro Mountain District, a distance of 17 miles, was completed, including a 7000-ft. transportation tunnel connecting the underground workings at Leopold with the railroad at Tyrone. Ground was broken for a mill 5 miles east of Tyrone. The Phelps Dodge interests purchased the Huston group, the Fortuna and the Parker claims at Tyrone.

The Santa Fe Gold and Copper Co. at San Pedro, in Santa Fe County, ran its smelting plant continuously from the first of the year until August, when a temporary shut-down occurred for the purpose of making repairs and improvements. Development work was continued in the mine during August and September, and ore of a higher grade was opened in a new part of the property. The mineshaft was retimbered and the smelting furnace rebuilt, and in October it was started and ran continuously to the end of the year.

Tennessee.—The entire output of copper comes from the Ducktown district, Polk County, in the extreme southeastern part of the state. There are two operating companies in the district, the Tennessee Copper Co., and the Ducktown Sulphur, Copper, and Iron Co.

"The district was one of the earliest large producers of this country. Operations began as far back as 1850, and from that time till the close of the Civil War there was a large production from the secondary chalcocite ores. When these were exhausted unsuccessful attempts were made to work the lean copper-bearing original sulphides, and in the late seventies operations were suspended and the smelter was shut down. The present period of activity began in 1890, since which time the district has been a steady producer, from the primary sulphide ores. The principal sulphide

is pyrrhotite, with subordinate pyrite, chalcopyrite, and sphalerite. In 1912 the ores of the district yielded 30.6 lb. of blister copper per ton, or 1.53 per cent. with an average of 7 cents in silver and gold per ton. The fact that little timbering is necessary, and the coal and coke supply from Tennessee and Virginia is ample and cheap, together with the available cheap labor, has made it possible for the present operating companies to mine and treat these low-grade ores at a profit."[1]

The production of copper in Tennessee for 1913 was 19,489,654 lb. as compared with 18,395,256 lb. in 1912, an increase of about 5 per cent. Of this amount the Tennessee Copper Co. produced a total of 13,493,140 lb. of copper, and the Ducktown Sulphur, Copper and Iron Co., 5,996,514 lb. The Tennessee Copper Co. is operating three mines, the Burra Burra, the London, and the Polk County, while the Ducktown Co. operates two, the Mary and the East Tennessee. Both these companies operate sulphuric acid plants, the revenue from which is said to be considerable, and in the future will probably be fully as important as the copper output.[2]

Utah.—Utah mines in 1913 produced over 10,250,000 tons of ore with recoverable gold, silver, copper, lead, and zinc, valued at about $43,000,000.[3] The tonnage shows an increase of about 32 per cent. but the value is but slightly above that of 1912. Notable tonnages of ore were mined and shipped daily from the Utah Copper mine of Bingham to its mills at Garfield, where the ore concentrated increased from 18,000 tons during the first part of the year to more than 21,000 tons daily, during the latter part of 1913. At the Ohio Copper Co.'s mill at Lark, Utah, about 2600 tons of low-grade copper ore was treated daily during the year. These large tonnages, with shipments that were made directly to the smelters from other large mines in Bingham make the total ore mined in 1 year the largest in the history of the camp, increasing from 6,567,948 tons in 1912 to over 9,300,000 tons of ore mined in 1913.[4]

The Utah copper production for 1913 amounted to 148,274,658 lb. as compared with 131,673,803 lb. in 1912. The mine output which has broken previous yearly records reached 158,200,000 lb. in 1913, which is 15 per cent. greater than the 1912 figures. Much of this increase was made in the production of "porphyry" ores, the bulk of which came from the Bingham Mining district.

The Utah Copper Co., of Bingham, leads all copper mines of the state, both in the magnitude of its mining operations and in the payment of dividends.

[1] Mining Dept., State of Tenn., 22 *Ann. Report.*, Dec. 1, 1913.
[2] U. S. Geological Survey.
[3] Preliminary estimate, U. S. Geological Survey.
[4] Progress at Bingham during 1913, *Salt Lake Min. Rev.*, Jan. 15, 1914.

President MacNeill in his report to stockholders of the Utah Copper Co. for the last fiscal year states:

"The gross production of copper in concentrates for the year 1913 was 119,939,809 lb. After making smelter deductions, a net production of 113,942,834 pounds of refined copper was obtained. In addition, there were produced 28,121.24 oz. of gold, for which the company received $20 per ounce, and 285,589.36 oz. of silver, for which the company received 59.582 cents per ounce.

"Our sales and deliveries of copper for the year were made at the gross price of 15.337 cents per pound, or, after deducting delivery charges, 15.167 cents. It will be noted that in our balance sheets and statements of income for the year our copper is valued at 14.976 cents, which is the resultant figure from the estimated price which was used in the various monthly statements and quarterly reports. The difference between the higher price of 15.167 received for the copper and the figure of 14.976 cents at which our income was computed is due to reducing to a lower valuation the inventory price of our unsold copper, which stood at the end of the year 1913 at 13.5 cents per pound.

"The net cost per pound of copper produced for the year, after deducting miscellaneous income, was 9.256 cents. No deductions, however, were considered from this cost for dividends received upon the stock of the Nevada Consolidated Copper Co., owned by your company.

"The net operating profit from Utah mining operations for the year amounted to $6,303,223.29. Miscellaneous income received during the year from outside investments, including the dividends received from the stock owned in the Nevada Consolidated Copper Co., amounted to $2,270,200.27; the total income, therefore, amounted to $8,573,423.56. Interest paid during the year amounted to $60,318.39; this amount being deducted leaves, as shown on the income statement, a net profit for the year applicable to dividends and for other capital purposes of $8,415,105,17.

"Dividends were continued quarterly during the year 1913 at the rate of $3 per share per annum, and amounting to $4,747,710, leaving as a surplus for the year after the payment of dividends, $3,765,395.17.

"There was set aside as depreciation an amount equal to 5 per cent. of the total cost of all plants and equipment, such sum amounting to $507,712.21, which leaves a net balance passed to undivided profits of $3,257,682.96. The total dividends paid, up to and including the dividends declared for the year under discussion, aggregate $20,989,930."

In his report Manager Director Jackling says:

"In all there were 83.23 miles of underground work in the property in Bingham and 24,812 ft. were done during the year. The surface work

has destroyed 58.67 miles of the work. During the year 14 additional drill holes were put down, amounting to a total of 10,153 ft. The total of drill holes on the property is 37,471 ft. Underground development during the year cost 17.72 cents a ton, as compared with 1.59 cents per ton on the total tonnage of all ores mined and shipped.

"At the close of the year 1912, the total ore-bearing area fully and partially developed was 217.26 acres. During the year 1913 this area was increased to 225.31 acres, and the calculated average thickness of development and partially developed ore was increased from 424.3 ft. to 444.5 ft.

"A revised estimate of the ore reserves was made, taking into account the additional development work done during the year, and this shows that previous to January 1, 1914, there had been developed in the entire property 316,220,234 tons of ore, of which quantity 268,000,000 tons are classed as fully developed. This tonnage includes about 27,700,000 tons of partially developed ore in the slopes of the steam-shovel workings. The addition to ore reserves for the year was 16,000,000 tons in excess of the tonnage mined during the year.

"The average assay of the fully developed ore is 1.59 per cent. copper, and the average assay of the partially developed ore is 1.15 per cent. copper, making the average assay of both classes of ore 1.47 per cent. There was mined from the entire property prior to January 1, 1914, a total of 277,280,234 tons of ore, averaging 1.465 per cent. copper, and the total reserves remaining, therefore, amount to 332,500,000 tons, averaging 1.47 per cent. copper. In making the calculations to determine the average assay of the ore reserves there were used 50,761 assays, representing 23,465 ft. of diamond drill and churn drill holes, 285,913 ft. of drifts, raises and winzes, and 7130 lin. ft. of steam-shovel cuts, or a total of 316,508 lin. ft. of development work."

According to the annual report of the Utah Consolidated Mining Co., Bingham, Utah, for the year ending Dec. 31, 1913, the mine produced 251,966 dry tons of ore containing 7,710,668 lb. of copper, all of which went to the Internatioual Smelting and Refining Co. for treatment. Of this ore 181,077 tons averaged 1.987 per cent. Cu, 0.056 oz. Au, and 0.705 oz. Ag, and 70,889 tons averaged 0.968 per cent. Cu, with good values in gold, silver and lead. Profits from the sale of this ore amounted to $630,829, after charging off expenditures on the plant. This is $63,891 greater than in 1912. Dividends amounting to $450,000 were paid during the year. Ore reserves in the Utah Consolidated Co.'s property are said to contain 287,038 dry tons of ore that will average 1.9 per cent. copper and 51,409 tons of 15.3 per cent. lead ore. Above the prophyry dike on levels 10, 11 and 12 there has been developed a body of ore containing

190,000 tons of 1.75 per cent. copper ore. Tests by an oil flotation process are being made to determine whether these and other low-grade ores can be profitably treated.

The Bingham, New Haven Copper & Gold Mining Co., located at the head of Carr Fork, shipped 11,500 tons of crude copper ore to the International smeltery, at Tooele, during the year, and treated a total of 43,000 tons of ore in the company's mill with a production of 22,000 tons of concentrates. These were also shipped to the Tooele smelter. A profitable year is indicated by the payment of dividends amounting to $68,600.

The United States Mining Co. in Upper Bingham has been operated during the year with the production of 114,506 tons of copper ore and 73,753 tons of lead ore. The company recently acquired additional territory by the purchase of an adjoining property, the Last Chance of the Nevada-Utah Mines Co., lying between the upper end of Carr Fork and Upper Bingham.

The Bingham Mines Co., according to its 1913 report, mined 38,987 dry tons of ore at the Dalton and Lark and Commercial mines during the year. The metal content of the ore was as follows: 1,122,955 lb. copper; 2,745,881 lb., lead; 179,117 oz. silver and 2995 oz. gold. At the Eagle and Blue Bell mine the output was 35,244 tons containing 157,596 lb. copper, 4,639,073 lb. lead, 417,279 oz. silver, and 7514 oz. gold. The income for the year was $230,836, of which $139,000 came from dividends on Eagle and Blue Bell Mining Co. stock, and $91,836 from operating the Dalton and Lark and Commercial mines.

The Tintic district made a production of about 13,000,000 lb. of copper in 1912, as compared with 10,900,000 lb. in 1911. The production of copper from the Tintic district is largely incidental to the production of other metals, and the separate figures for 1913 copper output have not been given out at the time of this writing. It is estimated that to the close of 1912 the total copper production of Tintic mines was approximately 103,900,000 lb. copper.[1]

According to the report of the Iron Blossom mine for the fiscal year ending Dec. 1, 1913, the production during the year totaled 25,358 wet tons of ore containing 3,902 oz. gold, 66,619 oz. silver, 3,188,474 lb. lead, and 377,922 lb. copper, representing a gross value of $567,143. The company paid $400,000 in dividends during the year.

The Centennial-Eureka mine was the most important producer of copper in Tintic in 1912 as in previous years, though important productions were made by the Mammoth, Grand Central, and other mines.

The Frisco district of Beaver County made a production of about 3,000,000 lb. of copper in 1912, as compared with 3,600,000 lb. in

[1] U. S. Geological Survey.

1911. The Cactus mine was the largest producer. In 1913, the South Utah Mines and Smelters' Co., Newhouse, Utah, produced a total of 1,883,129 lb. of copper.

Wyoming.—The mines of Wyoming produce a small amount of copper annually, those of the Hartville district being the chief contributors. In 1913 the production was 362,235 lb. as compared with 25,080 lb. for 1912.[1]

Copper in Foreign Countries

Africa.—The production of copper in Africa during the last 3 years is shown in report of Henry R. Merton & Co., as follows:

AFRICAN COPPER PRODUCTION.
(English tons.)

	1911.	1912.	1913.
Katanga	1,100	2,345	6,790
Cape Colony	4,480	3,870	3,220
Namaqua	2,500	2,500	2,500
Sundries	9,000	7,655	10,000
Total	16,980	16,370	22,510

The total copper output of Africa for 1913 shows a marked increase over that of 1911 and 1912, the greatest increase coming from Katanga, Belgian Congo. This district began to ship copper in 1909, and has developed rapidly from 24,504 lb. or 10.9 tons to 6.790 tons in 1913. The output for 1911 was 2,484,515 lb., valued at $367,252, and in 1912 5,462,515 lb. of blister copper valued at $793,693, and 10,877 lb. of ore worth $583 were shipped.[2]

The most important mines in the Kongo are the copper mines near Kambove operated by the Union Minière. The richness of these is being confirmed, and is well shown by the record of 1913 as compared with the previous 2 years in the following table.

PRODUCTION OF UNION MINIÈRE.

	1911.	1912.	1913.
Tons of ore treated	10,300	20,900	48,500
Average metal content, per cent	12–13	13–15	15–16
Total output of copper (tons)	986	2,404	6,420

The figures for 1913 cover a period of 11 months only so that the year's totals should be somewhat larger. During 1913 there was also produced 130 tons of copper matte. In November, 1913, 1015 tons of Kambove copper were landed at Antwerp and sold for $341 per ton.

The Luushia mine, on the Cape-to-Cairo Railway, 55 miles from the Lubumbashi smelters, produces nearly 100 tons of pulverulent ore, which is briquetted and makes excellent material for smelting. The smelters

[1] Advance Statement, U. S. Geological Survey.
[2] *Daily Consular and Trade Rept.*, Apr. 16, 1914.

are now run with a mixture of enriched ores from the Star mine and the briquets from Luushia, the latter improving the operation and increasing the output of the smelters. Twenty-two coke ovens have been started recently, and an equal number will be ready for operation early in 1914. The combined capacity of the 44 ovens, burning washed coal from Wankie, will be 3000 to 3500 tons of coke per month.

The real exploitation of the Kambove copper deposits commenced in June, 1913. The ore is recovered by quarries and up to the present time only the southern section of the mines has been worked with about 600 tons of ore as the weekly output, but this will shortly be brought up to 1000 tons. Certain mining engineers have expressed the opinion that the Kambove copper deposits will prove as rich as any in America.

The working forces of the Union Minière consist at present of 18 Europeans, 10 of whom are Belgians, and 330 native laborers. The net profit of the company in 1912 was over $85,000.

A great drawback to mining enterprises in Kongo is the question of labor. In the Katanga district alone it is said that 18,000 laborers will be required to work all the mines, and the actual supply falls far short of that number. There are several proposals to import Chinese labor, or to make some arrangement for obtaining natives from Angola. The activity in developing the mineral deposits of Katanga is shown by the fact that 369 special mining permits have been granted, of which 91 were for tin, 76 for copper, 65 for gold, 33 for copper and iron, 27 for tin and tungsten, and 23 for iron. Since June, 1913, one hundred seventy-four general mining permits have been granted.[1]

The Namaqua Copper Co. operating mines at Concordia, Little Namaqualand, South Africa has had a successful year. The report shows that 35,302 tons of ore were smelted during 1913 with a production of 4266 tons of matte, containing 2373 tons of copper. At the chief property, the Tweefontein, the reserve is estimated at 90,190 tons averaging 6 per cent. of copper. The net earnings for the year were £40,540, and a dividend of 22.5 per cent. amounting to £42,449 was paid to the shareholders.

Argentina.—The estimated production of Argentina for 1913 is 115 long tons as compared with 330 for 1912, and 1020 for 1911.[2] For a statement of mining conditions in Argentina see MINERAL INDUSTRY, XXI, 205.

Asia Minor.[3]—It is no exaggeration to say that copper can be found almost anywhere in the northern province of Asia Minor. The country inland for the whole of the distance from the Bosphorus to Batoum is

[1] *Daily Consular and Trade Rept.*, Apr. 16, 1914.
[2] Henry R. Merton & Co.
[3] *Min. Eng. World*, Jan. 3, 1914. Abstract of paper by G. M. Edwards.

copper bearing. The ancient empires of Sinope and Trebizonde owed their wealth and existence to the copper mines. The number of old workings is very large. As a rule the veins are narrow and rich, containing 20 per cent. and more of copper. There are many exceptions to this rule that are noteworthy. One is the Aghana mine and another is the so-called copper basin of Hendek.

The Aghana mine is situated practically in the center of Asia Minor (40° E., 38° 30′ N.), about 250 miles from Alexandretta. The mine is owned and worked by the state. Its situation precludes economic exploitation, but the government derived a revenue of £66,000 from the mine, of which £26,000 was profit, in 1912. Since 1892 the total production of black copper has been over 20,000 tons. The lowest production was 454 tons in 1897, and the highest was 1800 tons in 1912. The deposit is found on the top of a low plateau several hundred feet above the surrounding country. The region consists of basic igneous rocks, and the mine itself is in a broad belt of serpentine (peridotite) which traverses them. The actual deposit is oval in shape, and is nearly 700 ft. long, and 400 ft. wide at the widest point. All the workings are to be found within this area. So far the greatest depth attained is 80 ft. The deposit consists of massive iron pyrites and chalcopyrites without gangue. In general the ore contains 8 per cent. copper, but the bunches of chalcopyrite bring the average up to 15 per cent. No ore containing less than 10 per cent. is now worked. The mine is worked on the tribute system, and the price paid the miners by the government is 2 piastres per oke, or about £16 per ton. The government calculates that there is still 700,000 tons of copper ore in the Aghana mine that will average 10 per cent. copper.

The other deposit of importance is situated at Hendek, less than 80 miles from Constantinople, and about 20 miles from the railway station of Ada-Bazar, on the Bagdad railway. The copper is found in schist rocks, as impregnations, resembling greatly the Mansfeld deposits of Germany. It appears, however, that the Hendek beds are on the average thicker and richer than those of Mansfeld. The thickness of the impregnated beds varies from 1 to 7 ft., the average being 2 1/2 ft. From a great number of assays taken the copper content has been found to average 5 per cent.

Australasia.[1]—The aggregate value of the mineral production of Australasia during 1913 will fall considerably below that for the previous year. The gold yield of all the states shows a falling off but both New South Wales and Queensland show satisfactory advances in the production of industrial metals. Operations were checked at times at various

[1] Abstract of paper by W. P. Geary, "Mining in Australasia in 1913," *Eng. Min. Jour.*, Jan. 10, 1914; together with inserts from various sources by the author.

centers, but generally the work proceeded steadily. The same degree of attention was not given to the mineral industry as in previous years, the favorable season causing a diversion of energies to other channels, and consequently prospecting operations were more or less neglected. The total copper production of Australasia for 1913 as given by Henry R. Merton & Co. is 46,580 long tons as compared with 47,020 tons for 1912. Considering the inactivity at Mt. Lyell in the early part of the year, the reconstruction work at Mt. Morgan, strikes and other difficulties at Cloncurry and the Great Cobar, this showing is more than was to be expected.

Generally speaking, Australia has not responded to the improved prices that have ruled for the metal copper during the last year. Within the commonwealth itself no new copper enterprises have been entered upon, but it is possible that during the next year mines in Papua, which have been undergoing moderate development during 1913, will reach a producing stage. There is ample room for fresh copper-mining enterprise in Australia if the state governments, who control all the railroads, could be persuaded to connect well-known copper fields with the railway system. The only state which seems to recognize the value of her base-metal resources is Queensland, and as a result that province has jumped from a very insignificant position into the forefront of Australian copper producers.

Queensland will account for 23,000 long tons, which will be a shade less than her production for the previous year. Both the Mt. Elliott and Hampden mines in the Cloncurry district were tied up for several months through strikes, otherwise Queensland would have eclipsed her previous record.

From the annual report of the Mt. Elliott mine for the year ending June 30, 1913, the following summary is given: The net profit for the term, after provision has been made for depreciation on plant, development expense and all expenditures including options, etc., was £141,811, as compared with £158,443 for the previous year. Dividends to the amount of £202,836 were paid, a portion of the money distributed coming from money previously in hand. The furnaces were in blast for 7 1/2 months only, owing to labor troubles, and 41,633 tons of ore were treated, yielding 4673 tons of blister copper, containing 4631 tons of copper.

Labor troubles interfered considerably with operations at the Hampden Cloncurry mines during the first half of the year. Two months were lost as regards production, and development work was retarded by cessation of pumping operations for 3 or 4 months. Under the circumstances the company makes a better showing than might have been anticipated, the net profit being £66,398. The financial result was affected by

the fall in the price of electrolytic copper from £77 8s. per ton during the previous half year to £68 15s. per ton. Two dividends were paid, one in September and one in December amounting to £35,000 each, or a total of £70,000. Prospecting on the 350-ft. level of shaft No. 2 has during the latter part of the year proved the presence of what appears to be a very large body of pyritic ore that assays from 9 to 12 per cent. copper at various places along the vein. It averages from 5 to 6 ft. in width and has been explored 161 ft. along the strike, and the ore is apparently continuing to the north and the south; 600 ft. to the south, in shaft No. 1, at a depth of 413 ft. a well-defined lode 6 1/2 ft. wide, assaying 11 1/2 per cent. copper, was passed through. It is inferred that this is the southern extension of the same vein, and if so it will give the newly found lode very pleasing proportions, and will add much to the reserves of the mine.

The extension of the railways by the government continues, and presently it is expected that Mt. Cuthbert will add materially to production figures. Mt. Oxide, another high-grade mine in the Cloncurry field, is perhaps too remote to be considered as an impending producer. Upward of 100 miles of railway will require to be constructed before the rich ores of Mt. Oxide will reach the market. Mt. Morgan, the famous old gold mine, contributed 8630 tons to the Queensland figures for 1913. It is confidently expected that from March of next year Mt. Morgan will produce at the rate of 12,000 long tons per annum.

The conditions in western Australia have not altered materially during the year. From Whim Well and Phillips river, and sundry smaller shows combined, approximately 1500 tons of copper have been won, which is a few hundred tons below the record for the preceding year.

The condition in South Australia is much the same as it is in Tasmania. The Wallaroo and Moonta mines are the principal producers, and during the past year the Wallaroo mines produced 60,949 tons of ore from which 5148 tons of fine copper was extracted, as compared with 56,863 tons of ore containing 4703 tons of copper in 1912. The Moonta mines showed a slight decrease in ore tonnage from 7178 tons in 1912 to 6421 tons in 1913. The copper extracted from these ores for the 2 years is 831 and 789 tons respectively. The cementation plant at the Moonta mines produced 948 tons of precipitates in 1913, containing 728 tons of copper, while the Wallaroo mines during the same period produced 21 tons. The Wallaroo smelting works treated 70,671 tons of ore matte and precipitates during the year from which 7112 tons of copper, 2161 oz. gold, and 1000 oz. of silver were refined. The quantity of bluestone made was 13 3/4 tons. The tonnage from the rest of the state is about 500 tons of copper,

making a total of 7612 tons for South Australia, as compared with 6295 tons for 1912.

It is rumored in Kadina, South Australia, that the boring plant of the Wallaroo and Moonta Mining Co., operating near Boors' shaft, at the Wallaroo mines, has struck a new and rich make of ore, and that boring from different points has given adequate proof of its size and quality. At the other end of the mine, near Harvey's shaft, drives are being worked in really big lodes, thus proving the mine at both ends. If this is correct the Wallaroo mines can see another 20 years of prosperous life, but at present nothing authentic has been made public.

According to the report[1] of the Under Secretary for Mines, Mr. E. F. Pittman, the output of the copper mines of New South Wales for the year is valued at £598,733, which is an increase of £18,942 on that recorded for 1912. This satisfactory result is due to the enhanced yields from the Cadia and Burraga copper mines.

The Cobar district is the chief center of the copper mining industry, and the yield for 1913 is valued at £391,914, as compared with £410,155, or a decrease of £18,241 on the preceding year. Owing to the difficulty of obtaining skilled labor and the fact that the furnaces only worked for a period of 10 months on account of the failure of the coke supply, the production of Great Cobar Limited for the year was considerably below that recorded for the previous year.

The Kyloe mine at Adaminaby, which in previous years was a constant contributor to the production, ceased work in April last, and the company transferred operation to Drake. The yield from the Grafton Copper Co.'s mine at Cangai exhibits a decrease on that of the preceding year, due, it is stated, to industrial troubles, which considerably hampered productive work. The Lloyd Copper Mining Co. at Burraga furnished a very satisfactory output, which was valued at £92,070. The mine was producing for 11 months of the year, and during that time was shorthanded owing to the scarcity of miners, boodlers, and truckers. The Cadia copper mine yielded 832 tons of copper, valued at £54,159, which formed a valuable contribution to the total production. The mines in the Nymagee division also supplied good returns for the period under review. In the Dandaloo division, the various mines were more or less worked during the year, but the progress of the field is greatly retarded owing to the absence of communication with the State railway system. At the works of the Electrolytic Refining and Smelting Co. of Australia Limited, Port Kembla, the production of metals during the year included 14,388 tons of electrolytic copper. However, this was obtained principally by the treatment of mattes and ores imported from

[1] *Austral. Min. Stand.*, March 12, 191 .

other states, chiefly from Queensland, only a small portion of the copper being won from the products of the mines of this state.

The manager of the Queen Bee copper properties at Cobar states that the statement that the mine is worked out, even on the upper levels, is erroneous, and caused through want of experience and knowledge of the mine. What is urgently required is that more prospecting and development work be done on all these levels in the mine. There is, unbroken and broken, at least 45,000 tons of ore in the upper levels of the mine which will average over 5 per cent. copper, without taking into consideration those ore-bodies undeveloped on these levels. Together with the dump this would give a total of at least 70,000 tons, of which 45,000 tons are estimated to contain 5 per cent. and the balance 3 per cent. Taking copper at £50 per ton, it is estimated that the ore will realize £157,500. The manager considers the mine to be the best in the Cobar district, outside the Great Cobar, Limited, but its history shows the wasteful manner in which some mines have been worked in the past.

A new mineral field—the Fire Fly—has been discovered in New South Wales. It is situated in rough, little-frequented, mountainous country, upon the slopes of the Chandler river gorge, at an altitude of nearly 3000 ft. above sea-level and 1800 ft. above the river. The ore deposits were discovered in July last by a couple of prospectors. In an official report, Mr. Jaquet, of the State Mines Department, says: "Rich copper ore has for many years been known to occur in the locality, and a lode was found and worked by Messrs. Keys, of Hillgrove, in 1896, just above the level of the river near Hall's Peak. Messrs. Keys' discovery attracted considerable attention at the time on account of the richness of the copper sulphide ore, and the fact that it contained a considerable quantity of silver." Mr. Jaquet inspected the discovery at the time, and as the result of five samples he found that Keys' lode was worth about 40 per cent. copper and from 10 to 13 oz. of silver per ton.

Apart from the Mt. Lyell operations, Tasmania can hardly be considered a copper producer. The total for the state may be put down at 5200 tons, of which Mt. Lyell will account for 5000 tons. This company has now overcome the disorganization resulting from the disastrous fire, and it may be expected that next year will produce an additional 2000 tons.

It is shown in the half yearly reports of the Mt. Lyell M. and R. Co. for the term ended September 30, that work in the mining department for the period had resulted in the re-establishment of a normal scale of production in the two principal mines—the Mt. Lyell and the North Mt. Lyell. The after effects of the conflagration in the latter mine have been successfully and permanently overcome. The Mt. Lyell mine was worked on an increasing scale as required by the smelting of siliceous ores.

The South Mt. Lyell mine is being opened up and worked in conjunction with the Mt. Lyell mine, practically as portion of the same combined ore occurrence, though there is no direct connection between the two ore masses except the accident of close proximity to each other. At the Lyell Tharsis mine the open cut supplied a small quantity of siliceous metal-bearing flux, which was used in place of the North Mt. Lyell ore at the reduction works. Similarly operations at the Lyell Comstock mine were pushed for the supply of siliceous ore, but the restitution of the North Mt. Lyell ore, which is higher in metal value and more siliceous than the Lyell Comstock ore, and consequently more profitable to use, has again curtailed operations at this mine and restricted them to development for the present.

The South Mt. Lyell pyrites mass is of lower grade in all three metals than the pyrites of the Mt. Lyell mine. The cutting of the necessary stope galleries has been well advanced, so that the mine is near the producing stage. At the North Mt. Lyell the precipitation plant was kept in operation, treating the mine water from baling, and later on the usual mine flow. The output from this source was 146 tons of precipitates, containing 63 tons of copper. In addition 109 tons of precipitates, with 16 tons of copper, were cleaned up in the underground workings, and represent the metal precipitated by the steel and ironwork, etc., out of the water with which the mine was flooded. The total tonnage of precipitates for the half-year is, therefore, 255 tons containing 79 tons of metallic copper. The assay value of the ore treated was higher than that of the preceding period, and conforms to the estimated average value of the mine.

The total tonnage from all these mines for the half-year covered by the report is 142,614 tons, which yielded 2474 tons of blister copper containing 2442 tons of copper, 75.64 oz. silver and 1637 oz. gold. The total output since Aug. 10, 1903, to the end of the period amounts to 75,530 tons of copper, 6,273,542 oz. silver, and 160,849 oz. gold. The financial position of the company, after deducting £10,864 for prospecting and development work and £11,390 for 'depreciation of mine plant, etc., the net profit from all sources is £41,943. The total 'direct loss due to the disaster in the North Mt. Lyell mine amounts to £42,141. A sum of £21,282 was charged to profit and loss last half-year, and the balance £20,858 has been charged to the reserve fund. The company's liquid assets show a surplus of £486,488 15s. 2d. over liabilities.

The estimated production of the several fields for 1913 are as follows: New South Wales, 8,000 tons of copper valued at £550,000; Queensland, 23,000 tons estimated to be worth £1,580,250; South Australia, 6500 tons

PRODUCTION OF COPPER IN AUSTRALASIA.
(In tons of 2240 lb.)

Year.	New South Wales.				Queensland.		South Australia.		Tasmania.				Western Australia.		
	Ingots, Matte and Regulus.		Ore.		Copper, Tons.	Value.	Copper, tons. (a)	Value.	Blister copper.		Copper ore.		Copper ore, tons.	Copper (b) tons.	Combined value.
	Tons.	Value.	Tons.	Value.					Tons.	Value.	Tons.	Value.			
1906	8,964	£781,645	791	7,882	10,077	£916,546	8,208	£718,609	8,708	£862,444	2,234	£72,480	7,430	.....	£50,337
1907	8,963	716,759	1,135	11,015	12,756	1,028,179	7,831	690,000	8,247	832,691	788	36,975	3,727	1,602	203,376
1908	8,679	496,564	392	6,248	14,961	893,535	5,628	338,000	8,833	603,063	1,185	6,588	2,503	479	57,091
1909	6,857	423,642	100	1,095	14,494	853,196	5,697	334,584	8,638	586,419	1,688	21,619	6,959	833	104,844
1910	8,435	450,491	4,455	35,766	16,387	932,489	5,102	306,120	8,193	553,822	671	13,150	6,309	1,281	95,928
1911	10,618	578,198	1,482	11,904	20,384	1,151,351	5,922	332,500	6,022	385,797	2,286	22,852	9,825	829	78,364
1912	8,990	560,025	2,044	19,766	23,120	1,698,280	6,295	461,500	5,136	430,965	1,392	9,479	13,607	1,703	120,158
1913	9,153	595,826	308	2,907	23,655	1,660,178	7,161	488,986	4,569	364,332	1,967	10,932	(c)14,339	(c) 82	145,613

(a) Small amounts of copper ore, and sulphate not included here. (b) Ingots and matte. (c) Exports.

valued at £446,875; Tasmania, 5200 tons of copper, worth £357,500; and West Australia, 1500 tons of copper valued at £103,500. More detailed statistics for the years 1905 to 1912 inclusive are given in the table above. Queensland leads all the Australasian fields by a large margin, producing more than three times the amount credited to New South Wales which comes second.

Prospecting had been carried on in a number of districts which promise to add greatly to the future output of Australia. According to the *Australian Mining Standard* a good deal of attention has been given to the Phillips River field of late. This field consists of a number of smaller mining districts, included among which are the Ravensthorpe, Desmond, Kundip, and West River. In view of the large quantities of Sulphide ores (carrying gold, silver and copper) known to exist in the field, the State mining engineer has expressed the opinion that pyritic smelting could be successfully conducted with a consequent large saving in fuel. All ore is now being shipped to Port Kembla, but the government has lately leased the Ravensthorpe smelters recently held by the Phillips River Gold and Copper Co., which will probably give fresh impetus to copper mining in the district. The owners of the surprise mine have about 100 tons of 27 per cent. ore ready for shipment, as a result of a few weeks' work for four men. At the Marion Martin two parties of leasers are doing well, and at the Last Chance mine another party

is breaking 19 per cent. sulphide ore. Many other small properties are giving promise of development in the near future.

Bolivia.—The following figures of the output of copper in Bolivia are calculated on barrillas (dressed ore containing chiefly metallic copper) with an average content of 80 per cent. Cu:

Year.	Weight in Kilos.
1908	2,877,605
1909	3,096,605
1910	3,211,987
1911	2,950,024
1912	4,681,374
1913(a)	3,657,600

(a) Henry R. Merton Co., estimate.

The important and extensively exploited deposits of Bolivia are those of the Corocoro region yielding native copper, which occurs in bedded deposits varying from 7 to 10 ft. in thickness, but occasionally reaching 30 or 40 ft. The average value is 2.5–3 per cent. but "bunches" as high as 12 per cent. are occasionally met with. The outcrops are distinguished by copper oxides. The Caraugas province is also productive of native copper, but the deposits have not been developed to any extent as yet.

Canada.—The production of copper in Canada consists of smelter products, matte, blister copper, etc., together with the estimated recoverable copper in exported ores. The total output in these forms during 1913 was 76,975,832 lb. valued at $11,753,440 as compared with 77,832,127 lb. worth $12,718,548 in 1912. These figures show a decrease of 856,295 lb. and a difference in cash returns of $965,108. The production by districts was as follows:

CANADIAN COPPER PRODUCTION.
(In pounds.)

	(a)1911.	(a)1912.	(b)1913.
Quebec	2,436,190	3,282,210	3,455,887
Ontario	17,932,263	22,250,601	25,884,836
British Columbia	35,279,558	50,526,656	45,791,579
Yukon	.....	1,772,660	1,843,530
Total	55,648,011	77,832,127	76,975,832

(a) Mineral Production of Canada for 1912, Ottawa, 1914.
(b) Mineral Production of Canada, Preliminary Rept. for 1913, Ottawa, 1914.

The province of Quebec shows an important gain which is due to the increased output of the mines producing pyrite ores in the Eastern Townships. The figures for 1912 show an increase over those of 1911, and the production of each of these 3 years exceeded that of any previous year since 1897, so that the output of 1913 established a new record of production for Quebec during the last 15 years. Copper has been produced in this province at a rate varying from 1,000,000 to 6,000,000 lb. annually for many years.

The Ontario production comes almost entirely from the nickel-copper

ores of the Sudbury district, in which the copper is a minor constituent. The 1913 production was the largest so far recorded from this province. The chief producing companies are the Canadian Copper Co., at the Creighton and Crean Hill Mines, and the Mond Nickel Co., operating the Victoria and Garson mines. Smaller mines are the Alexo and the Dane. During the year 1912 the Alexo mine near Kelso mines, Ontario, shipped a good tonnage of nickel-copper ore to the Mond Nickel Co.'s smelter at Victoria mines. The total tonnage of nickel-copper ore smelted in 1912 was 725,065 tons. During the same year 41,925 tons of Bessemer matte was produced, containing 11,116 tons of copper and 22,421 tons of nickel. The value of the matte was about $6,303,102. Cobalt ores shipped to American smelters also carried a small amount of copper.

To encourage the refining of nickel, cobalt, copper, and arsenic ores within the province of Ontario, the Ontario government offers a bounty on each pound of these metals produced and refined in the province. Refined copper or the copper content of copper sulphate receives a bounty of 1.5 per cent., metallic copper receives 1/2 cent per pound, the total not to exceed $60,000 in any one year. The Act providing for the payment of this bounty is known as "The Metal Refining Bounty Act."

In 1913 British Columbia had an output of 45,791,579 lb. of copper, as compared with 50,526,656 lb. for 1912. The copper production in this Province comes mainly from ores with very low copper content, which behave variably when smelted, often with heavy losses in the slag that may be as much as 25 per cent. or more of the copper in the ore. There are in British Columbia 94 active copper mining concerns, as compared with 159 copper-producing companies in all Canada.[1] According to direct returns the 1912 production was divided among the districts of the province as follows: Boundary district, 65.8 per cent. of the total; Rossland mines, 4.1 per cent.; and Coast district, 30.1 per cent. The ore deposits of the Boundary district form at present the most important copper deposits in Canada. They occur in mineralized zones in altered lunistones, at different horizons, but generally in the lower or outer portions. The ore is of uniform grade self-fluxing, consists essentially of finely disseminated chalcopyrite, with pyrite and hematite or magnetite, and a gaugue of epidote, garnet, quartz, calcite, and chlorite.[2] The ores of this district are treated at the Granby smelter, at Grand Forks, operated by the Granby Consolidated Mining, Smelting and Power Co. This company's mines at Phoenix furnish a large part of the ore for the Granby works, but custom ores are also handled. The ore reserves at the mines at Phoenix have not been fully maintained, being now reduced to 5,613,-

[1] "The Copper Handbook," 1912–1913.
[2] "Economic Minerals and Mining Industries of Canada," 1913.

000 tons, with recoveries of 17.68 lb. of copper per ton of ore. According to the Annual Report of the fiscal year ending June 30, 1913, 22,688,614 lb. of copper were produced during the year, as compared with 13,231,121 lb. for the year preceding. There were also 324,326 oz. silver and 47,266 oz. gold produced as compared with 225,305 oz. silver and 33,932 oz. gold produced in 1912. The operating profit for the year was $1,214,-599, as compared with $583,379 for 1912.[1]

At the Hidden creek mines, Anyox, Observatory Inlet, the Granby Co. invested $979,461 in 1912, and during the past year $1,958,724 additional was spent in exploration work and the erection of the new 2000-ton smelter which has just been completed. A late estimate of the available ore in the company's Hidden Creek mines places the quantity at approximately 9,000,000 tons, with a copper content of 2.2 per cent.

A start was made on Mar. 16, 1913 to smelt ore at the new smelter at Anyox. Power for these works is obtained from nine large Pelton wheels. Two direct compressors are operated one for machine drills in the mines, and the other for the blowers for the blast-furnaces, of which there are three, blowing engine for converter plant, and other purposes.

According to Mr. E. E. Campbell, of the engineering staff of the Granby Co., several new properties have been acquired during the past year and a half. One, at Valdes Island, Alaska shows fairly high-grade copper ore, and plans have been completed for the installation of a plant there. The Mamie mine, on Prince of Wales Island, Alaska, was also acquired, and an option has been taken on the Copper Queen mine on Toxada Island. A lime quarry, situated on Portland canal has also been purchased, and is now in operation.

The Consolidated Mining & Smelting Co., of Canada, with reduction works at Trail has had another very successful year, according to the report of Pres. W. D. Mathews, Sept. 13, 1913. The total tonnage treated was 407,124, having a gross value of $8,335,668, which is an average monthly increase of about 2,400 tons. The metal production amounted to 3,454,814 lb. copper, 48,325,352 lb. lead, 3,244,408 oz. silver, and 186,017 oz. gold. The net profits amounted to $998,367.14 out of which three dividends with a total of 8 per cent. were paid, leaving at present a balance of $1,717,650.49 on the credit side of the profit and loss account of the company. The company's mines in Rossland show an increase in ore development due principally to the Le Roi mine, in which new ore has been found. Deep development work in the War Eagle mine has also resulted in an important new ore discovery. The Monte Christo, Iron Horse, Abe Lincoln, and Virginia claims adjoining the Rossland properties have been acquired by the company, during the year. At Kimberly,

[1] *Can. Min. Jour.*, April 1, 1914.

ores of the Sudbury district, in which the copper is a minor constituent. The 1913 production was the largest so far recorded from this province. The chief producing companies are the Canadian Copper Co., at the Creighton and Crean Hill Mines, and the Mond Nickel Co., operating the Victoria and Garson mines. Smaller mines are the Alexo and the Dane. During the year 1912 the Alexo mine near Kelso mines, Ontario, shipped a good tonnage of nickel-copper ore to the Mond Nickel Co.'s smelter at Victoria mines. The total tonnage of nickel-copper ore smelted in 1912 was 725,065 tons. During the same year 41,925 tons of Bessemer matte was produced, containing 11,116 tons of copper and 22,421 tons of nickel. The value of the matte was about $6,303,102. Cobalt ores shipped to American smelters also carried a small amount of copper.

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The total output of copper ore from Chile during an average year, 1909, amounted to 500,000 long tons, carrying 9.21 per cent. copper. This ore came from 775 different mines. Of this great number, 100 mines produced 375,000 tons of ore while the remaining 675 mines together produced but 125,000 long tons. This gives an average output for each mine of 185 long tons per year, which shows at once the small scale upon which the numerous mines of Chile have been operated. With the exception of a few important mines the work is carried on in a most primitive manner, without machinery.[1]

The more important mines that are producing ore on a large scale, or getting ready to do so, by thoroughly modern methods, are the Braden Copper Co. and the Chile Copper Co. Both of these concerns are controlled by American capital.

The Braden Copper Co.'s property is situated in the province of O'Higgins, 94 miles from the coast, at an altitude of 7500 ft. The mines are connected with the Central railroad line belonging to the state by a private narrow-gage line 50 miles in length, and by a good wagon road 34 miles long, both built by the company. The copper deposit is in the crater of an extinct volcano, and the outlying porphyritic rock. The zone of mineralization is confined to the edge of the crater which has a circumference of about 5 miles. The mineralized part of the porphyry run is about 160 ft. in thickness, and has been prospected 2200 ft. in depth, showing 16,660,760 tons of 2.65 per cent. copper ore. Of this, Tiente No. 1–4,040,834 tons carries 2.75 per cent. copper; probable ore, 8,749,444 tons at 2.63 per cent. copper; possible ore, 18,742,745 tons at 2.61 per cent. copper. In addition to the last item, possibilities of 15,000,000 tons, chiefly from above Tiente No. 1., may be speculated upon.

The company produced 9,500,000 lbs. of copper in 1912. It was expected that 25,000,000 lb. would be produced in 1913, but the output has evidently been considerably less than that, for during the first 8 months the company produced 11,034,000 lb., at that rate the 1913 production would be about 16,500,000 lb. It has been estimated that the Braden Copper Co., when operating at full capacity, can produce copper for 7.4 cents per pound. On the basis of 25,000,000 lb. production and a cost of 7.5 cents per pound the estimated net earnings on a 15-cent market are 72 cents per share of stock of par value $5.

In the Chuquicamata district in northern Chile, the Chile Exploration Co. is preparing with great haste an extensive equipment with which to mine and treat what is said to be the largest ore-body in the world.[2] The ore deposit is 8000 ft. north and south and practically

[1] Juan Blanquier, "Copper Mines of Chile," *Min. Sc. Pr.*, Mar. 29, 1913.
[2] *Min. Sc. Pr.*, Apr. 4, 1914.

1000 ft. wide. The drilling shows richer values in depth than at the surface, and that the copper minerals are thoroughly disseminated through minute fractures in the rock. These minerals consist of brochantite, atacamite, chalcanthite and cuprite. In depth veins of chalcocite and chalcopyrite have been encountered, but these are not now being considered, as the upper oxidized ore must first be mined away before the sulphides are exposed. The sulphate ores will be mined by steam shovel and treated by a leaching process that has been specially devised by the company.

The first unit of the Chuquicamata plant is designed to treat 10,000 tons of ore per day, and work is being pushed so rapidly that it is now confidently expected that the plant will be ready for operation by March 1, 1915. This plant will produce 120,000,000 lb. of copper per year, and later another plant of equal capacity will be built, and by the summer of 1917 it is expected the Chuquicamata will be producing at the rate of more than 240,000,000 lb. per year. The ore reserves are now claimed to be over 200,000,000 tons, with unknown but evidently encouraging possibilities of much more when deeper explorations are made.

China (By T. T. Read).—China is an importer of copper; the metal brought into that country has increased from 4,800,000 lb. in 1910 to 14,400,000 lb. in 1912. Of the imports 80 per cent. of the metal comes from Japan, and is largely used in the coinage of 1/2 cent pieces, and manufacture of other objects made of brass. There is a fair production of copper by native methods in Yunnan, but no data as to output are available. Duclos, a number of years ago, estimated it at 2,000,000 to 3,000,000 lb., but it has probably declined since. There is a small smelter near Lauchaw, in Kausu, but no statement of its output has been made.

Cuba.[1]—The El Cobre mines, Province of Santiago de Cuba, produced 62,482 tons of ore during 1913, of which 7594 tons were shipped to the United States for smelting and refining. The remainder was treated by concentration. A flotation plant has been erected at El Cobre, under the direction of the Minerals Separation Co., of London, having a daily capacity of 400 tons. Tests made with a 50-ton unit showed a recovery of 85 per cent. which is considered to be very good in view of the complex nature of the ore. The task of unwatering the old workings has been continued to a depth of 1100 ft. and it is anticipated that the mine will be completely unwatered during 1914.

Japan.—The estimated production of copper in Japan in 1913 is approximately 72,000 tons,[2] as compared with 62,939 for 1912, an

[1] B. B. Lawrence, "El. Cobre Mines in 1913," *Eng. Min. Jour.*, Jan. 10, 1914.
[2] Henry R. Merton & Co.

increase of about 14 per cent. From a production of only 32,000 tons in 1903 Japan has been steadily developing a larger yearly output, sufficient to take care of the rapidly expanding home consumption and also furnish a large quantity of export.

The most important mines and their output during the last 3 years are as follows:

COPPER PRODUCTION OF PRINCIPAL JAPANESE MINES.
(In tons of 2000 lb.)

	1911.	1912.	1913.
Ashio	8,483	10,530	11,900[1]
Kosaka	6,606	8,867	10,100[1]
Hitachi	6,243	8,704	10,600[1]
Besshi	7,573	8,537	9,500[1]
Osarusawa and Homaki	2,172	2,385	.....
Ikuno	1,654	1,884	.....
Furokura	2,014	1,719	.....
Ogoya	1,246	1,540	.....
Arakawa	1,410	1,413	.....
Other mines	20,252	23,299	42,100
Total, short tons	57,653	68,878	80,600
Total, metric tons	52,302	62,486	73,200

"The Ashio mine stands first in output, not only in Japan, but in the Far East. The recent improvements of the mines and the works, and the completion of a railroad to the mine have made possible a marked increase and great economy. The future of the property is bright. A fire visited the property late in December, resulting in about 80 houses being burned near the Tsudo adit. No damage to the mines themselves occurred. The production of copper from Besshi is expected to increase hereafter steadily and the mine has large reserves. The Kosaka and Hidachi mines stand high in total production, but partly because of the smelting of custom ores from several mines. The Ashio and Besshi are the producers of copper from their own ores."[1]

For many years Japan has exported copper to foreign countries, and the amounts have steadily increased from year to year. The rapid development of wire making, and the manufacture of electrical machinery calls for large quantities of copper to supply the home consumption. In 1912 the domestic needs were 27,630 tons, and in 1913 it has been estimated that 35,500 tons were consumed in the manufacture of wire, machinery, brass, etc., in Japan. The exports of copper from Japan during the last 10 years, according to statistics prepared by Otto Reimers & Co., Yokohama, are as follows:

[1] *Min. Sci. Pr.*, Feb. 21, 1914.

COPPER EXPORTS OF JAPAN.
(In tons.)

	Europe.	America.	China.	India.	Totals.
1904	3,780	.....	15,560	2,171	20,611
1905	2,813	.....	17,242	52	20,107
1906	23,997	3,628	5,757	82	33,464
1907	13,670	3,569	14,002	410	31,651
1908	25,000	5,515	2,220	2,766	35,501
1909	22,170	9,528	1,589	2,088	35,375
1910	21,116	8,846	957	4,218	35,137
1911	17,288	11,009	3,688	2,322	34,307
1912	23,351	6,917	7,317	805	38,392
1913	19,843	5,543	13,320	3,574	42,280

The total exports show a steady increase during the 10 years covered by the statistics from 20,611 tons in 1904 to more than double that amount in 1913. Since 1906 the bulk of copper from Japan has gone to Europe, the yearly amounts varying somewhat. The greatest variations have been in the exports to China.

Mexico.—In 1913 the smelters of Mexico produced 116,435,566 lb. of copper as compared with 162,295,545 lb. in 1912, the decrease being directly chargeable to the effects of the political troubles of the country. This is, however, a fair production, in view of the serious conditions that have come about as a result of the present war. When peaceful conditions are re-established the production will become normal again.

The Greene Consolidated Copper Co. in Sonora is one of the large producers. In 1912 this company's properties produced 48,157,847 lb. of copper. During the first 10 months of 1913 this company produced 36,685,000 lb. of copper, and it is estimated that the total for the year will reach 43,000,000 lb.

The Cananea Consolidated Copper Co., Sonora, Mexico, had an output of 37,050,574 lb. of copper in 1913, exclusive of that produced from Miami concentrates.

The Cananea Consolidated Copper Co. closed the year 1912 with a 5 days' strike of the Mexican laborers, who demanded shorter hours, an increase of wages, and native bosses. An 8-hour day shift was granted and 90 per cent. of the strikers returned to work on Jan. 2, 1913. The Cananea Co. had been producing between 6,000,000 and 7,000,000 lb. of blister copper per month from the treatment of company ore, Miami concentrates and custom ores. Railroad communication with the United States was cut early in March through the operations of the opposing armies and on Mar. 22 the 4000-ton concentrator was closed owing to a shortage in the fuel supply. Work was discontinued in the mines producing concentrating ore and a large exodus of Americans resulted. The camp was attacked by the constitutionalist army on Mar. 26 and surrendered after a 3 days' siege. Conditions became so serious during

April that a complete shutdown was expected due to the lack of oil to run the smelter and power plant. Four of twelve mines, the Elisa, Eureka, Capote and Kirk, were operating on reduced shifts, all developments had ceased and 2500 Mexicans had been thrown out of work. The reverberatories and 50 per cent. of the blast-furnaces had been blown out or banked and the output fell to 3,000,000 lb. of blister per month. Many cars of Miami concentrates, accumulating at Naco, were shipped to Phelps-Dodge smelting plants in the United States for treatment. The production of 3,000,000 lb. was maintained until gradual improvement of political conditions warranted a return to normal. Although 6,000,000 to 7,000,000 lb. are being shipped at present, the company is operating at only 40 per cent. capacity, since one-half of this production is obtained from the treatment of Miami concentrates and custom ores. Four of eight blast-furnaces, two reverberatories, three converters and part of the concentrator are now operating.

The Democrata Mining Co., in the Cananea district, was compelled to close down for a short period early in the year, but normal operations were later resumed. The Calumet and Sonora was similarly affected.

The Moctezuma Copper Co., at Nacozari, was not seriously affected by the revolution. Development work for the year increased 40 per cent. over 1912. Thirty-nine per cent. of this development was done in ore. Besides developing ore below the Porvenir adit, large stopes of good ore have been opened on two levels in ground that had been abandoned as barren. The concentrating plant treated 603,654 tons of ore assaying 3.557 per cent. copper, and yielded 135,057 tons of concentrates containing 13.376 per cent. The net earnings of the company were $2,402,447, of which $1,950,000 were paid in dividends.

The Nacozari Consolidated Copper Co. operated almost continuously and reports excellent ore in the breast of the main tunnel. A new 100-ton concentrator was erected. The Moctezuma-Arizpe Development Co. was threatened with a shutdown but latest reports indicate a return to almost normal conditions. The Mines Co. of America closed the La Dura but is operating the Creston Colorado; the San Antonio Copper Co. suspended operations. At the Cieneguita Consolidated and in the vicinity, everything is at a standstill.

Norway.—The production of copper in Norway for 1913 was 11,610 tons[1] of which the Sulitelma Mines produced 4610 tons. The total tonnage of ore produced was about 147,750 tons, of which 125,000 tons consisted chiefly of pyrite ore that was exported, 11,280 tons were smelted, and 11,470 tons of concentrates were produced by the Elmore process.[2]

[1] Henry R. Merton Co., Ltd., London.
[2] "L'exploitation minière an Norvège en 1913," *Echo des Mines*, Mar. 15, 1914.

From 11,570 tons of pyrite and 14,580 tons of concentrates (Elmore) which was partly made up of old stock, there was obtained 1385 tons of Bessemer copper. The mines of Birtavarre produced about 450 tons of Bessemer, and those of Röraas 556 tons. In all, Norway produced 2750 tons of copper by treatment at Norwegian plants, valued at about 3,300,000 crowns, or $891,000 at the Norwegian ports.

A 55 year's lease followed by non-compensatory expropriation, has been granted by the state to a company, presumably foreign, for the operation of the well-known Aarundal Copper Mines, situated in Telemarken, Norway. During the last 50 years these mines have been exploited by numerous British companies, with negative results. The ore, a bornite, originally described as containing 20 per cent. copper has seldom within the last 15 years exceeded that amount even after concentration. Horse haulage costing $1.56 per ton, followed by two trans-shipments and canal dues besides oversea freight to South Wales add greatly to the costs of production. There are, however, a number of promising occurrences outside of the old workings, which with the installation of aerial transport to avoid horse-haulage to Bandak lake, may give new life to the mines of this district.[1]

Peru.—The copper production of Peru in 1913 shows a slight increase over the record of the previous year. The figures published in the *Daily Consular and Trade Report* for the 2 years are 27,940 metric tons in 1913 as compared with 27,840 metric tons in 1912. The official Peruvian statistics give the production for 1913 as 26,970 metric tons, which differs but slightly from the Consular Report. The output of fine copper is made up as follows: bars, 20,340; matte, 4462; shipping ores, 3138; total, 27,940. The entire output is exported, principally to the United States.

The most important producers are the Cerro de Pasco Mining Co., and the Backus & Johnston Co., which together make up over 90 per cent. of the total output. The production for the year is divided among these companies as follows.[2]

	Pounds.
Cerro de Pasco Min. Co	44,830,107
Backus & Johnston Co	10,341,120
Others	5,428,793
Total	60,600,000

The year 1914 will probably show a marked increase in the copper production of Peru as a result of improvements in smelting facilities made by the Cerro de Pasco Mining Co., and the Backus & Johnston Co. during the past year. The Cerro de Pasco Co. did not average 50 per cent. of its smelting capacity principally because of the shortage

[1] "Norwegian Copper Mines," *Eng. Min. Jour.*, April 11, 1914.
[2] *Min. Sci. Pr.*, March 21, 1914.

of fuel. However, with the increased output of the Quishuarchancha coal mine which now averages 250 tons per day, the utilization of waste gases from the reverberatory furnaces, and the introduction of electric power transmitted from the recently constructed hydro-electric plant at Oroya there will probably be no coal shortage in 1914.

After spending 4 years in reorganization and reconstruction the Backus & Johnston Co. is meeting with profitable results. The company's smelter is essentially a silver-copper plant and produced 1,950,000 oz. of silver in 1913. The silver ores from the Casupalca mines, as well as the custom ores obtained in the region, are dependent in a measure upon the Morococha mines which supply the necessary iron, as well as copper and silver. Blister copper shipments will be made in 1914 instead of the present matte and ore exported to the United States.

The Morococha district is attaining considerable importance as a producer, and will be a large factor in contributing to the copper, and to lesser degree, the silver production of Peru. The vigorous plan of development planned by the two principal producers, the Backus & Johnston Co., and the Morococha Mining Co. has barely begun, yet the combined monthly output of the two companies under present conditions is over 12,000 tons, including the ore from the many leased properties of the Backus & Johnston Co. Most of the custom ore shipped is sent to Casapalca. A small privately controlled furnace is operating in the district having sintering pots as an important feature, and ships 50 to 60 tons of copper matte monthly to the Cerro de Pasco smelter. The source of the ore is from small mines.

The plant of E. E. Fernandini, several miles west of La Fundicion, continued as a silver-copper smelting plant, the matte averaging 1500 oz. silver per ton and 55 per cent. copper; the year's output was about 1,500,000 oz. The silver ores are brought from the Colquijirca mine and the copper ore from Cerro de Pasco.

The minor shipments of copper ores were somewhat increased with the higher price of the metal. Several properties were under development besides those producing in a small way. The Sociedad Cuivre de Huaron continued developing its properties 35 miles southwest of Cerro de Pasco; there are said to be 100,000 tons of 12 per cent. copper ore "in sight." The Ferrobamba region was practically inactive; the treatment problem was studied but without commercial results. Several properties in different parts of the country were optioned by various foreign syndicates and sales may eventually be consummated.

Of the smaller producing copper mines the Sociedad Minera Quirurilca, Ltd., in the Department of Libertad, is the most important shipper, averaging about 100 to 150 tons of 35 per cent. copper ore per month,

which goes to the United States. Southward, in the Department of Ancasho, the Empresa Minera San Juan, Ltd., of Tarica, is obtaining better results with its 15-ton smelter; the matte exported averages 35 per cent. copper and 300 oz. silver, with a little gold. In the same department, the Magistral properties, belonging to Garaborri y Compania, have been optioned to local people who intend to develop them. At Vinchos, near Cerro de Pasco, the Yanamina Mining Co. has recently blown in a 30-ton furnace which will smelt copper and silver ores that will be shipped to Cerro de Pasco. Lack of adequate transport, and its high cost, handicap the development of the copper possibilities of Peru, under certain conditions local smelting could be made a profitable business.

Russia (By J. P. Hutchins).—The production of copper in Russia for 1913 shows an increase of about 2.5 per cent. over the production of 1912, and is another record breaker for Russia. The total production for 1913 was about 42,000 tons divided among the several fields as follows: Ural Mountain region 25,200 tons; the Caucasus 10,080 tons; the Kirghiz Steppes 5040 tons; Finland, Poland, and the Altai Mountains 420 tons; and by-products from the chemical works 1260 tons. The production has grown rapidly during the last few years, the figures for 1913 being about six times those of 10 years ago, and three and one-half times those of 1906. The comparatively light increase for 1913 was due to reconstruction work which has heen carried on at many of the old mines during the year. With the improvements now completed 1914 should show a marked increase in copper production over the year just passed.

Consumption was in excess of production to the extent of 8200 tons, which was supplied by imports. The per capita consumption of copper in the Russian empire is only about 1/2 lb. per year as compared with 7.3 lb. in the United States. A similar set of figures can be adduced for the other base metals. If the per capita consumption of copper in Russia were the same as that of the United States there would be a demand for 600,000 tons per year. This comparatively low demand at present is due to the general backwardness of the country which is still in the rural and pastoral stage. As an excellent illustration, though there are numerous cities in Siberia with populations over 100,000, there is but one electric street railway, that of Vladivostok. However, when more rapid progress sets in, and electric railroads, telephones, and telegraphs come into more general use throughout the empire, the proportion of copper used will be materially increased.

During the past 6 years nearly all the Russian copper producers have been combined in a Trust called the Myed (Russian word for copper).

Its ostensible purpose is to control the production of copper, regulate prices, etc. Inasmuch as the demand for copper has exceeded the supply by about one-third, this syndicate has not been of any real importance. Similar combines for other metals and minerals, however, have been important factors where output exceeded the demand. The total productivity of the Myed in 1912 amounted to 93.8 per cent. of the total copper production of the country, as compared with 90.3 per cent. in 1911, and 80.8 per cent. in 1910. These figures show that the Trust is becoming more and more important, and has already nearly complete control of the copper production.

Ural Mountain Region.—The copper mines are situated on the east flank of the mountains and extend along a well-defined belt for about 300 miles, in a region of old rocks, granites limestones, and crystalline schists. The ore is pyritic, and generally occurs in large, regular, and easily mined deposits, and presents no metallurgical difficulties.

The most notable mines are those of the Kyshtim Corporation which is controlled in London. In 1913 this company produced about 8000 tons of copper, or about one-half of the total Ural production. These mines were formerly operated by a Russian company with heavy losses. Later an English company took over the business and improved matters somewhat. Finally, the mines passed into American control and very radical changes were instituted in an attempt to put the business on a paying basis. The inefficient local employees were discharged and foreigners were employed in all important technical positions as well as in many minor places. Then a new set of Russians was hired and made to do as is done in good mining and smelting works in foreign countries. As these latter men learned the business the foreigners were gradually discharged, and now all but the manager of the mine are Russians, and it is claimed that the lowest cost copper in the world is that from Kyshtim.

Caucasus Region.[1]—The Caucasus Copper Co., which produces about 4000 tons of copper per year, or about half of all that is produced in the Caucasus, is controlled in London. Nearly $10,000,000 have been spent, much of it in solving a smelting problem due to a high siliceous content of pyritic ore. There are said to be reserves in this company's mines of more than 5,000,000 tons, containing 3 1/4 per cent. copper. The Dzansul Copper Smelting Works belonging to the Caucasus Copper Co., has doubled its production since 1911. In 1912 the Dzansul works yielded 3056 tons of copper. At present they are treating about 800 tons of ore per day, and new construction in under way to increase the tonnage to 1800 tons per day. The largest smelting works in the

[1] Abstracted in part from *The Mining Journal*, London.

Caucasus are those of the Societe Metallurgique du Caucase, situated beside Alaverdoff copper mines. Just recently this company has acquired the Zangezur copper mines in the Elizabetpol government, which are the richest in the Caucasus, and have begun the reconstruction of the concern in order to produce a much larger quantity of copper. The Kedabek Smelting Works, belonging to the Siemens Co., does not intend to increase its production. This company smelted 1550 tons in 1911, but only 1430 tons in 1912. The electrolytic works there, which were the first in Russia, have not been used since 1901. The production of the Kedabek Works is declining. However, the Siemens Co. is erecting new smelting works. In the Caucasus a further large number of copper deposits are known, for which probably there is an interesting future.

Kirghiz Steppes.—This is the third largest copper producing region of Russia, and possesses natural conditions that should favor mining operations, rich ore and abundant coal. The large mines of this region are also in the hands of foreigners, and foreign methods prevail. The Spassky Co., controlled in London, has large bodies of copper ore containing more than 10 per cent. copper, and at present this company is producing nearly 4000 tons per year. The Atbasar Co., in the Atbasar district, province of Akmoninsk, is installing smelting works to produce about 5000 tons annually. In this district of Atbasar a Russian company with large deposits of copper ore has plans for large smelting works that are to be built in the near future. The district is much handicapped by the great distance to the railroad and its greatest development will come when the railway, which has been authorized by the government, is built. The present cost of haulage over the 400 miles that separates the works from the railway is £5 per ton, and this presents a serious impediment to the full development of this promising region. There are large reserves of 3 and 3 1/2 per cent. copper ore in the Kirghiz Steppes, but these must wait for the advent of cheap transportation before they will be developed.

Finland, Poland and Altai.—With the exception of the last of these three districts, there is thought to be no great possibilities for development. The Altai, however, should become a large producer. This region has been worked since prehistoric times by most primitive methods, principally for silver and gold. The word "Altai" means gold in the language of the Turks. There are many old abandoned copper mines in Altai that were worked intensively 150 years ago, or even longer; records show that considerable amounts of ore containing 10 to 15 per cent. copper were mined and hauled 300 miles to be smelted. These mines are to be reopened. It has been proved that there are large ore-bodies of complex

ore, containing, along with other metals, about 2 per cent. of copper. When the Altai Railroad, which is now being built, is finished these mines can be worked on a large scale, and their yield will add materially to the annual copper production of Russia.

Duty and Price.—There is a protective duty of 5 roubles per pood, or almost 7 cents per pound on all copper that is imported into Russia. This makes the selling price for copper 25 to 33 per cent. higher than it is in New York, and acts as a strong stimulant to exploration and mining in Russia. While there has been rapid growth in the rate of production, there has also been some increase in consumption, though the yearly imports have been steadily declining. Home production has gained on the increased consumption, and unless the copper demand grows rapidly within the next few years, the domestic output will be more than able to satisfy it.

Spain.—The official figures of copper-ore production for 1912 are 3,364,294 tons of copper bearing pyrite. The copper output of Spain and Portugal for the last 3 years, according to estimates and figures compiled by Henry H. Merton & Co., is as follows:

COPPER OUTPUT OF SPAIN AND PORTUGAL.
(English Tons).

	1913.	1912.	1911.
Rio Tinto	36,320	39,925	33,385
Tharsis	3,220	3,375	3,395
Mason & Barry	3,135	3,540	2,920
Sevilla	1,510	1,390	1,530
Other mines	9,650	10,700	9,700
Total	53,835	58,930	50,930

Rio Tinto.—The most important copper mines are those of the Rio Tinto Co. The output of the Rio Tinto mines for each year since 1903 is shown in the following table.

OUTPUT OF RIO TINTO MINES.
(In Long Tons.)

Year.	Pyrites for Shipment.	Ores for Local Treatment.	Total Mined.	Average Copper Contents.	Copper Produced at Mines.	Pyrites Sold.	Washed and Other Sulphur Ores Sold.
1903	688,919	1,229,619	1,918,538	2.390%	21,565	667,748	118,174
1904	672,344	1,276,475	1,948,819	2.340%	21,218	663,744	157,810
1905	627,336	1,202,768	1,830,104	2.363%	19,530	660,724	308,184
1906	655,328	1,268,388	1,923,716	2.411%	21,287	632,307	477,843
1907	641,858	1,265,090	1,906,948	2.417%	21,251	607,944	619,814
1908	604,275	1,115,610	1,719,885	2.265%	24,256	589,815	668,477
1909	604,799	1,184,188	1,788,987	2.349%	24,364	600,946	569,604
1910	637,020	1,509,945	2,146,765	2.097%	22,790	578,443	683,605
1911	649,215	1,536,390	2,185,605	2.144%	21,880	662,259	841,964
1912	698,399	1,708,573	2,406,969	2.180%	25,623	668,861	977,812
1913	652,168	1,207,403	1,859,571	2.190%	21,062	635,900	825,408

Owing to labor troubles, and to the lower average price of copper, Rio Tinto made a somewhat lower record for 1913. During the year 652,-

168 tons of ore were mined for shipment and 1,207,403 tons for smelting and leaching, as compared with 698,399 tons of shipping ore and 1,708,570 tons for local treatment in 1912. The quantity of pyrite invoiced to consumers for both copper and sulphur content was 635,900 tons, as against 668,861 tons the preceding year. The delivery of sulphur ore, washed and crude, totaled 825,408 tons as compared with 977,812 for 1912. The production of metallic copper was 21,062 tons, and copper contained in pyrite amounted to 15,258 tons, a total of 36,320 tons as compared with 39,925 tons for 1912, average copper content of all the ore mined was 2.19 per cent. which is practically the same as for 1912. The accounts show a profit of £1,673,372, of which £81,250 was distributed as 5 per cent. preferred dividend, and £1,406,250 on the ordinary shares, being at the rate of 75 per cent. For 1912 the ordinary shares received £1,678,500, or 90 per cent.

The Cordoba Copper Mining Co., operating a series of mines 10 miles northeast of the city of Cordoba in the south of Spain, has produced 119,069 tons of copper ore during 1913, which is 28,910 tons more than was mined during the previous year. The production of blister copper was 3500 metric tons, as compared with 2377 tons for 1912. The income was £230,705, at a cost of £147,384. After allowing for depreciation, expenditures on other properties, etc., a net profit of £53,518 remained out of which £40,000 was distributed in dividends, at 20 per cent. On the San Rafael and eastern sections which contain the workings on the Cerro Muriano lode, 86,127 tons of ore were raised of which 55,498 tons were sent to the concentrating plant, 8894 tons hand picked, were sent direct to the smelter, and 6762 tons of fines sent to be sintered, and the rest rejected. The Murex plant treated 15,655 tons of middling and dump material, averaging 1.3 per cent. copper, and produced 1281 tons of 10 per cent. concentrates, the average recovery being 63 per cent. The smelter treated 31,389 tons of ore; concentrate, and sinter, producing 6837 tons of matte averaging 49.7 per cent. copper; the converters produced 3500 tons of copper bars. Development in the San Rafael section has given excellent results but these are offset by the lower grade ore found in other sections so that the copper in reserve has fallen from 200,025 tons of 3.35 per cent. copper to 206,489 tons of 3 per cent. copper ore.

Venezuela.—The estimated output of Venezuela for 1913 is 125(long tons as compared with 1340 tons for 1912. The South American Copper Syndicate of Aroa, Venezuela, declared a dividend of 350 pe cent. on its capital stock of 150,000 shares, which were issued at 2s. ($0.40 the profit thus disbursed amounting to $213,640, or £43,900. The output of the year ending April 30, 1913 gave a net profit of £33,500, which wa added to a balance of £10,400 to make up the £43,900. The life of thi

property at the present rate of production is estimated to be at least several years, though it is virtually impossible to form an exact opinion.[1]

Bibliography

Ball, Sydney H.—Sandstone Copper Deposits at Bent, New Mexico. *Min. Sci. Pr.*, July 26, 1913, p. 132.

Bartels, Bergassessor.—Die Lage der Kupferindustrie Russlands im Jahre 1912. *Zeit. Berg. Hütten Salinenw.*, **61**, Part 3, 1913, p. 451.

Blanquier, Juan.—Copper Mines in Chile. *Min. Sci. Pr.*, March 29, 1913, p. 507; Apr. 19, p. 583.

Botsford, C. W.—Disseminated Replacement Copper Deposits. *Eng. Min. Jour.*, March 22, 1913, p. 620.

Brinsmade, R. B.—The Copper Mines of the Sierra Magistral, Mexico. *Mex. Min. Jour.*, Aug., 1913, p. 394.

Clendenin, Jos.—An Analysis of the Copper-Metal Situation. *Min. Eng. World*, April 19, 1913, p. 770.

Clifford, James O.—Formation and Growth of Disseminated Copper Deposits. *Mines and Minerals*, April, 1913, p. 189.

Douglas, James.—Handling Flue-Dust at the Copper Queen Smelter. *Min. Sci. Pr.*, Dec. 13, 1913, p. 929.

Douglas, James.—Historical Sketch of the Copper Queen Mine, Arizona. *Min. Eng. World*, March 15, 1913, p. 525.

Eilers, A.—Occurrence of Some of the Rarer Metals in Blister Copper. *Min. Eng. World*, Nov. 15, 1913, p. 884.

Emmons, Wm. H.—The Enrichment of Sulphide Ores. *Bull.* 529, U. S. Geol. Surv.; *Min. Sci.*, Aug., 1913, p. 102.

Gilbert, Chester G., and Pogue, Jos. A.—The Mount Lyell Copper District of Tasmania. Reprint from Proc. U. S. Natl. Museum, Govt. Ptg. Office, Washington, D. C., p. 26.

Graton, L. C.—Investigation of Copper Enrichment. *Eng. Min. Jour.*, Nov. 8, 1913, p. 885.

Gwyn-Williams, R. H.—Mining in Katanga Congo Belge. *Min. Jour.*, Aug. 23, 1913.

Haupick, E. de.—The Copper Mines of the Ural Mountains. *Min. Eng. World*, Jan. 18, 1913, p. 101.

Haupick, E. de.—Year's Progress of the Russian Copper Industry. *Min. Eng. World*, Dec. 27, 1913, p. 1159.

Hore, R. E.—Copper Mining in Michigan. *Can. Min. Jour.*, Oct. 15, 1913, p. 643.

Hore, R. E.—Magnetic Origin of Sudbury Nickel-Copper Deposits. *Can. Min. Jour.*, July 15, 1913, p. 437.

Hore, R. E.—Sudbury Nickel-Copper Industry. *Mines and Minerals*, Feb., 1913, p. 383.

Jandorf, M. L.—Copper in York County, Pennsylvania. *Min. Sci. Pr.*, Mar. 1, 1913, p. 346.

Kershaw, John B. C.—Copper Production and Price Statistics, 1907–1912. *Elec. Rev. and West. Elec.*, May 17, 1913, p. 1011.

[1] *Daily Consular and Trade Report.*

MACE, CLEMENT H.—Ore Pockets of the Arizona Copper Co. *Min. Eng World*, Jan. 4, 1913, p. 13.

MARTIN, G. A.—Early Copper Mining and Smelting in Arizona. *Min. Jour.*, May 3, 1913, p. 881.

NOBLE, ALBERNON.—Mining Possibilities in Turkestan. *Min. Mag.*, Dec., 1912, p. 444.

SALES, RENO.—Origin of the Butte Chalcocite. *Min. Sci. Pr.*, Sept. 20, 1913, p. 453.; *Eng. Min. Jour.*, Sept. 6, 1913, p. 439.

SPERR, F. W.—Failures of the Rule of Following the Ganging in the Developments of Lake Superior Copper Mines. *Proc. Lake Superior Min. Inst.*, 1912, p. 238,

STEELE, HEATH.—Copper Prices, Consumption and Supply. *Eng. Min. Jour.*, Dec. 6, 1913, p. 1061.

STEELE, HEATH.—The Cost of Copper." *Eng. Min. Jour.*, Aug. 9, 1913, p. 231.

STORME, WM. H.—Geology of the Woody Copper District, California. *Eng. Min. Jour.*, Oct. 4, 1913, p. 635.

STUTZER, O.—Ueberblick uber die nützbaren Lagerstatten Katangas. *Metall. u. Erz.*, Aug. 30, 1913, p. 679.

WEBSTER, J. P. B.—Mining in Kyshtim, Siberia. *Min. Mag.*, April, 1913, p. 279.

Weed, W. H.—"The Copper Handbook," 1912–1913.

WIERUM, H. F.—Ore Bedding by the Tennessee Copper Co. *Eng. Min. Jour.*, Sept. 6, 1913, p. 435.

WOODBURN, J. ALLEN.—Mining Copper Ores at Massina. *Jour. Chem. Met. Min. Soc. So. Afr.*, Aug., 1913, p. 53.

————.—Copper Production of the World. *Eng. Min. Jour.*, May 25, 1913, p. 1066.

————.—Geological Notes on the Lake Superior Copper Formation. *Proc. Lake Superior Min. Inst.*, XVIII, 9 (1912.)

————.—The Copper Situation. *Min. Sci. Pr.*, Oct. 25, 1913, p. 639.

————.—The Question of Copper Metal Prices. *Min. Eng. World*, Nov. 8, 1913, p. 821.

————.—World's Copper Production and Consumption in 1912. (*Min. Eng. World*, Jan. 25, 1913, p. 142.

————.—World's Copper Production. *Min. Eng. World*, April 19, 1913, p. 755.

METALLURGY OF COPPER IN 1913

BY L. S. AUSTIN

Summary of Progress in 1913.—A number of smelteries, constructed in 1912, have been brought into operation as described in detail. Those of the Southwestern United States treat ores of too low grade in sulphur for self-roasting, and in one case pyrite has been added to the charge in the reverberatory furnace to ensure sufficient matte-fall.

For roasting, the Herreshoff, the Wedge and the MacDougall, all multiple-hearth roasters, are largely employed. Sorenson shows that by

air instead of water-cooling of the rabble arms, in 18-ft. MacDougall furnaces, where the concentrate is near the limit of non-fuel roasting, and with the aid of oil-firing, it is possible to increase from an output of 45–55 tons to as high as 100 tons and over, daily. We give particulars of similar success in increasing tonnage with 16-ft. MacDougall furnaces at Great Falls. The Dwight-Lloyd sintering machines are coming more into use for copper ores. The Tennessee Copper Co. is using three machines, the Cerro de Pasco, the Tacoma, and Trail Smelteries two each, and the Mond Copper Co. one. At Cerro de Pasco, ores containing 25 per cent. sulphur, are successfully sintered.

With the increasing amount of fine concentrate to be treated, the reverberatory furnace is becoming more employed. At Great Falls, Mont., and in Russia, the direct, coal-fired, non-reversible regenerative type is being installed. For fine concentrates this method of smelting avoids flue-dust loss, and can easily treat ores low in sulphur.

The Great Falls upright type of converter is coming into increased use, the 12-ft. being preferred to the 20-ft. one. The Pierce-Smith horizontal converter has also been giving good results.

The leaching of copper ores in receiving increased attention, sulphuric acid being much used, and for precipitation (at least in part) electrolytic deposition, completed in some cases by the use of scrap-iron.

Ores and Ore Handling

Butte Ores.[1]—Representative ores from Butte, Montana, as received and treated at the Great Falls smeltery, are in two classes, the first class going to the blast-furnaces, the second class to the concentrator, and of this composition:

TABLE I

	Per cent. Cu	Oz. Ag	Oz. Au	Per cent. SiO_2	Per cent. Fe	Per cent. S	Per cent. Al_2O_3.	Per cent CaO
First class	6.06	2.0	0.015	51.2	13.6	17.3	8.1	0.30
Second class	3.55	1.26	0.008	58.5	9.4	11.6	11.7	0.10

In addition, a more complete analysis of the second class ore shows: As, 0.37 per cent.; Sb, 0.025; MgO, 0.25; K_2O, 2.34 and Na_2O, 0.11 per cent. Leaving out Cu, As, Sb, S and Fe, the gangue minerals amount to 73 per cent.

From the concentrating mill the product of the coarse jigs, about one-third the total of the mill, goes to the blast-furnaces; the fine concentrate to the MacDougall roasters and thence to the reverberatories. Analyses of these products are given in Table II.

[1] *Trans. A. I. M. E.*, XLVI, 1936.

TABLE II

	Per cent. Cu	Oz. per Ton		Per cent. SiO_2	Per cent. Fe	Per cent. S	Per cent. Al_2O_3	Per cent. CaO
		Ag	Au					
Coarse concentrate.....	12.16	3.9	0.019	20.7	25.9	33.8	4.4	0.3
Fine concentrate.....	8.84	3.0	0.021	18.1	28.5	35.9	5.3	0.3

Screen tests of these products and of flue dust, show that the flue dust is all finer than 0.5 mm. in size. From 7 to 10 per cent. of the ore and 55 per cent. of the fine concentrate, which goes to the MacDougall roasters, is finer than 0.5 mm., thus accounting for a considerable production of flue dust.

The Freeland Charging Machine.[1]—This is used at the smeltery of the Ducktown Sulphur, Copper and Iron Co., Isabella, Tenn. The apparatus comprises an endless chain pan-conveyor of the width of the open-top furnace, and mounted on a frame which also carries the platform for the operator and the two motors, one to propel the machine, one to drive the apron or pan-conveyor. In operation, the car is run under feeding chutes beneath the furnace-bins. While the ore is discharging from any chute the machine is traversed in such fashion as to evenly spread the ore and the other constituents of the charge. It is then brought, motor-end first, longitudinally over the furnace latching itself to the water-cooled cover of the furnace, and pushing it back. The conveyor of the car is now set in motion and its contents are dropped while, at the same time, the charging machine is moved over the furnace in the opposite direction. The rate of this movement determines the distribution of the charge, which may be added evenly throughout, or wherever in the furnace it is most needed. When loading, the machine deflectors at the chutes can be so arranged as to send the ore to the right or left, thus piling it up near one of the long sides or on the median line. This gives elasticity in the distribution of the charge.

The Messiter System of Ore-bedding at the Tennessee Copper Co. and the Calumet and Arizona Copper Co.[2]—This system has been described and discussed in these volumes (See Vol. XV, 249; XVI, 356; XVIII, 191; XIX, 188 and XXI, 228).

H. F. Wierum gives further particulars, especially as to its advantage where the furnace gases are used for making sulphuric acid. The Burra Burra ore of the Tennessee Copper Co. may vary from day to day from 10 to 20 per cent. in silica, and correspondingly effect the composition of the slag and the performance of the furnace. Thus, the furnace gas

[1] *Min. Sci. Pr.*, CVI, 443; Modern Copper Smelting, Levy, p. 188.
[2] *Eng. Min. Jour.*, XCVI, 435; Salt Lake Min. Rev., Oct. 30, 1913.

night vary from 7 per cent. SO_2 in the morning to 3 per cent. in the afternoon. With the bedding system it has been possible for a period of 2 months, to obtain a gas rarely below 6 per cent. SO_2 or over 6.8 per cent.

The installation at Copperhill consists of two beds holding 7500 tons each and two smaller ones of 3000 tons each, an aggregate of 21,000 tons. The system (not including the sampling mill) cost roughly $150,000 or about $7.00 per ton stored. Altogether there is some 3000 ft. of belt conveyors of 30 in. to 16 in. width, travelling 200 ft. per minute. The superstructure is of wood instead of steel as at Cananea.

The bed, when formed, is triangular in cross-section, 35 to 40 ft. across and 16 ft. high, having 23 tons per running foot. The larger beds are 300 ft. long, the smaller ones 150 ft. Bedding is done on the day shift only, and including sampling, requires 10 to 12 men. Reclaiming is done at any time in the 24 hours, and takes nominally a machine runner, three belt-tenders and one or two laborers per shift. Belt renewals amount to $5000 per year.

Comparing the bedding system with the older way of obtaining the ore from bins it was found:

(1) That 2.8–3.2 per cent. of coke is used as against 4.5–5.5 formerly.

(2) That the present tonnage per furnace per day is 580 as against 460–520 tons formerly.

(3) The advantage for steadiness in the quality of the gas has already been mentioned.

Roasting and Smelting

Sintering Ore at High Altitudes.[1]—R. L. Lloyd states, that at Cerro de Pasco, at an elevation of 14,000 ft., it is possible to directly sinter ore containing 25 per cent. of sulphur without the production of excessive heat, where at the lower altitudes the limit is 12 to 15 per cent. This is due to the fact, that at that altitude the density of the air is but 58 per cent. of what it is at sea level, and so intensity of combustion is lessened. At ordinary altitudes some elemental sulphur is driven off in sintering, so that with the higher content of 25 per cent., much more is produced. This goes into and through the exhaust fan, but does not take fire, because again of the feeble action of the air. The ordinary vacuum at the fan, of 4 to 6 oz. per square inch, has been found sufficient.

The Crouse Equipment for Dust-prevention in the MacDougall Roasting Furnace.[2]—This improvement, by George S. Crouse, at the Great Falls plant, of the Anaconda Copper Mining Co., is intended to lessen the production of flue dust, a serious fault of the typical MacDougall roaster.

[1] *Min. Sci. Pr.*, CVI, 908.
[2] *Trans. A. I. M. E.*, XLVI, 1419.

In Figs. 1–5 are shown plans of hearths, Nos. 1, 2, 3, 4 and 6, and a sectional elevation of the modified furnace.

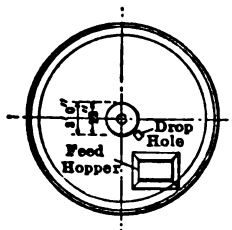
Dropping from the feed-hopper through the roof over No. 1 hearth at its outer edge, the charge travels inward to the extra drop-hole of hearth No. 1, this hole being 7 by 8 in. in size and located 4 in. from the edge of the regular 40-in. center drop-hole. The two center rabbles, one on each arm, move the material away from the center. The concentrate therefore all falls through the extra drop-hole, twice per revolution. It here falls through the "receiving boxes" or tubes, which just clearing the roof, extend to the charge surface below. The rabble arms, being in line with one another, the receiving boxes are in proper position when the ore is falling. The charge now travels to the exterior 12 by 22-in. drop-holes of hearth No. 2, falling through the third-hearth receiving-box to the floor of that hearth. Travelling to the center of hearth No. 3, it here falls through two extra drop-holes to No. 4 hearth. The fourth-hearth rabble-arms are set at right angles to the others, and carry on their ends "spark catchers" or plates intended for catching the sparks formed as these arms are pushing material through the side drop-holes of the fourth hearth, thus preventing the building up of incrustations on the roof above them. Any incrustations forming on the plates are easily knocked off. At this hearth, as well as at the fifth, where the opening is central, the material drops through a rapidly ascending gas current. This increases the formation of flue dust, but on the other hand, it was realized that the more intimate contact of the ore with the hot gas current resulted in a more vigorous combustion, thus favoring the rapid elimination of the sulphur still remaining, and a better maintenance of the heat on the lower floors.

A comparative test of the Crouse Furnace and the MacDougall furnace, gave the data tabulated below:

TABLE III

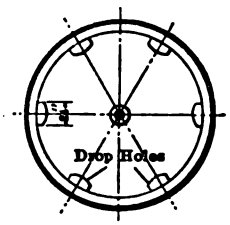
Test period: 12 m., May 24, to 9 a.m., May 29, 1912

Average.	MacDougall Furnace. (No. 1.)	Crouse Furnace. (No. 3.)
Tons concentrate treated per 24 hours (wet weight)	67.157	68.493
Per cent. of moisture in concentrate treated	8.0	7.9
Tons of concentrate treated per 24 hours (dry weight)	61.78	63.079
Tons of calcine produced per 24 hours	39.372	42.706
Assay per cent. sulphur in calcine	10.3	9.6
Tons of total products, excluding flue dust, per 24 hours	40.531	44.334
Per cent. of dry weight of feed recovered in above products	65.6	70.3
Per cent. of copper fed recovered in above products	78.6	87.0
Per cent. of sulphur fed eliminated from above products	81.3	81.2
Calculated by Cu Method.		
Pounds of flue dust per 24 hours	21,049	13,422
Pounds of flue dust per dry ton fed	341	213
Flue dust, per cent. of dry weight of charge	17.0	10.7



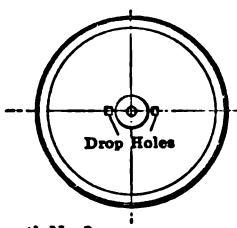
Hearth No. 1

The center drop hole is now used as a gas passageway only, and extra drop hole for concentrates.



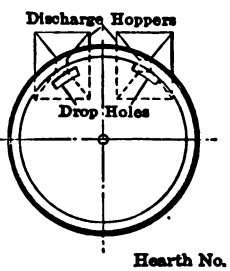
Hearths Nos. 2 and 4

Usually one or more of these side drop holes are covered to damp the air current.



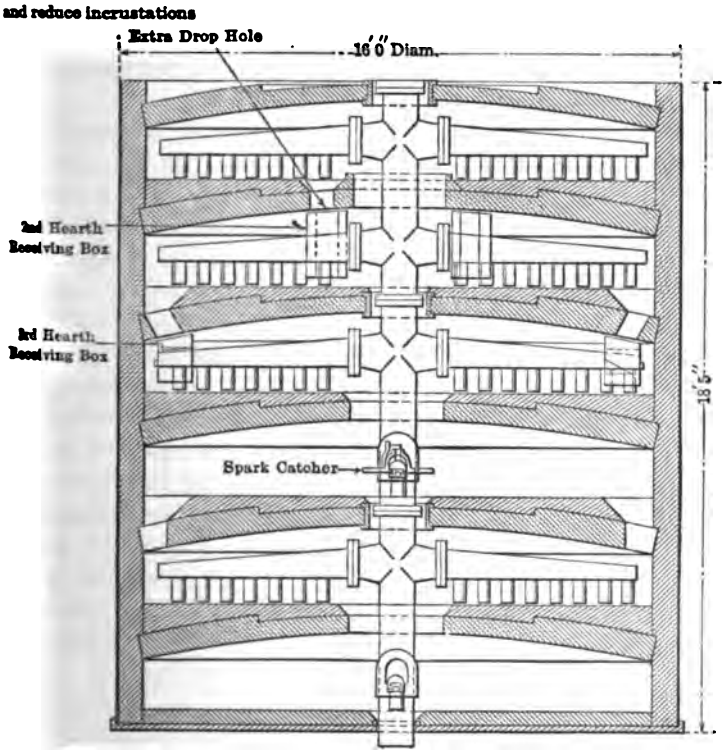
Hearth No. 3

The two extra drop holes through which the calcines fall to the hearth below, localize and reduce incrustations



Hearth No. 6

The discharge drop holes are 8 in. wide and 28 in. long on outer arc.



FIGS. 1 to 5.—Crouse equipment for dust prevention in MacDougall furnace.

Increasing the Capacity of the MacDougall Roaster.[1]—In a paper by Frank R. Corwin and Selden S. Rodgers, entitled "Increasing the Efficiency of MacDougall Roasters at the Great Falls Smelter of the Anaconda Copper Mining Co.," the writers give an account of extended experiments upon the twenty-two 16-ft. six-hearth roasters of that company.

Prior to the year 1909, the capacity of the roasters was 36.1 tons daily. With the introduction of the new flue system[2] the draft in the MacDougall dust-chamber was increased from 0.225 in. of water to 0.9 in., and in the flue necks from the furnaces to the cross flue, from 0.139 to 0.93 in. As a result of the increased draft, the output per furnace was increased to 45.7 tons per day. Any increase of the feed over this raised the percentage of sulphur in the calcine, and caused the furnaces to become too hot, so that they crusted up, especially on the roof above the third-hearth drop-hole, necessitating an excessive amount of cleaning of the crust, with its consequent delays.

To increase output, the first aim was to supply more air, and to stir the ore more frequently. To this end the furnaces were operated under full draft (1.1 in. of water), and with four doors open on the lower or sixth hearth; also the revolutions of the shaft were increased from one in 53 to one in 38 seconds. This prevented increase in depth of the bed, despite increased tonnage, and the ore was stirred more frequently, thus driving off the sulphur faster.

To lessen the amount of heat developed as the result of increased feed, first class screenings were mixed with it to reduce and regulate the temperature of the furnace. For fluxing purposes limerock is added to the calcine, but this is now fed to the sixth hearth of two of the roasters, and thus is avoided the possibility of the larger pieces of it wedging and injuring the rabbles when passing clear through the furnace.

To reduce the heat formerly concentrated on the roof above it, the area of the third-hearth center drop-hole was increased to 52 in. This spread the heat more and at the same time diminished the velocity of the upward flowing gases, so that excessive crusting was avoided. A year later it was found better to retain the 40-in. drop-hole, but to provide in the third hearth two extra drop-holes next to the center one. The inner rabbles on the third-hearth rabble arms were set to push the ore away from the center, and hence all the material dropping from the third to the fourth hearths was forced to pass through these extra holes. This meant dropping the whole feed four times a revolution, instead of continuously through the center drop-hole. Naturally, this localized

[1] *Trans. A. I. M. E.*, XLI, 1389.
[2] MINERAL INDUSTRY, XVI, 251.

the incrustations at the extra drop-holes, which were also more accessible for barring off.

Finally, to obtain at the edge of the second hearth sufficient heat to ignite the incoming concentrate, two of the six drop-holes of the hearth were closed. This concentrated the ascending hot gases at four points, thus ensuring a sufficient temperature for prompt ignition of the ore.

Comparing the earlier with the later performances of the MacDougall department during monthly periods, we find:

In April 1910, an average of 12.9 roasters put through 46 tons of concentrate and screenings with 7.9 per cent. sulphur in the calcine, being a total of 17,778.4 tons for the month.

In April 1913, with an average of 7.95 furnaces working, there was put through 77.1 tons of cupriferous material with 8.9 per cent. of sulphur in the calcine, or 18,369.4 tons for the month. We may note that with this large daily tonnage the percentage of first class ore-screenings which could be handled was also increased.

Commonly, a charge containing 85 per cent. of fine concentrate and 5 per cent. of first class ore screenings would prevail. They have this average percentage composition:

TABLE IV.

	Cu	SO_2	FeO	Al_2O_3	CaO	S
First class ore screenings	7.10	46.9	16.6	9.7	0.1	17.4
Fine concentrate	7.45	24.0	32.8	5.1	0.1	33.4

Due to the fewer furnaces running in 1913, there was a saving of labor per 24 hours over April, 1910, of three furnacemen, three laborers pulling lumps, and 5/6 feeder.

The present 16-ft. roasters are to be substituted by 24-ft. MacDougall roasters using the reinforced concrete hearths described below.

The Herreshoff Roasting Furnace.[1]—In Fig. 6 is shown the improved six-hearth Herreshoff roasting furnace with air-cooled arms and central shaft, 21 ft. 7 in. in diameter by 19 ft. 5 in. in height of shell and set with a head-room above the floor of 6 ft. 10 in.

The central shaft is double, the inner one 18 in. in diameter, the outer one 40 in. in diameter. The rabble arms extend to the 18-in. shaft with outlets at each rabble arm. Air under pressure is forced through the central shaft, passes to the outer end of the rabble arm, and back to the annular space between the two shafts. The heated air is taken off at the top, and is brought back through channels in the outside walls to the

[1] *Min. Sci. Pr.*, CVII, 683.

lower hearth to be used for air supply at that hearth. The hearths for outward discharge have drop-holes 18 by 14 in. in size, the central drop-openings are 8 ft. in. diameter. To each hearth are provided six doors, 24 by 16 in.

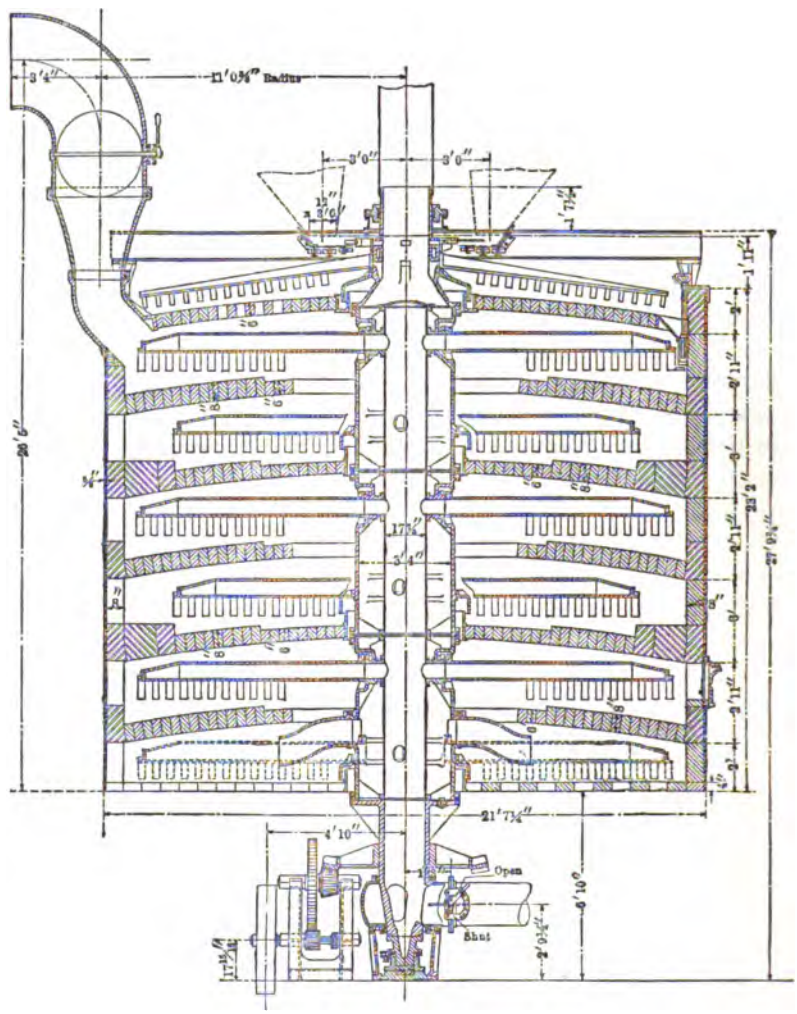


FIG. 6.—Herreshoff furnace.

The ore is fed upon the top of the furnaces from two hoppers. Just below each hopper is a steel plate, and the ore is swept off the plate by a rotating finger, which passes between the hopper and the plate. Control of the feed is given by cast-iron sleeves at the end of the hoppers, which can

be raised or lowered. Falling upon the top of the furnace, the ore is worked to the periphery by the upper set of rabbles. These are simply dropped to place in the rabble arm and can be replaced without stopping the furnace. Feed from the furnace top to the first hearth is regulated by means of a plate, which varies the discharge openings of the drop-holes.

The makers give for their new 20-ft. roaster, with seven hearths (including the drying one), hearth area 1810 sq. ft., weight of metal parts 82,000 lb., weight of special fire brick 168,000 lb., and the sulphur that can be removed in 24 hours, 16,000 to 40,000 lb.

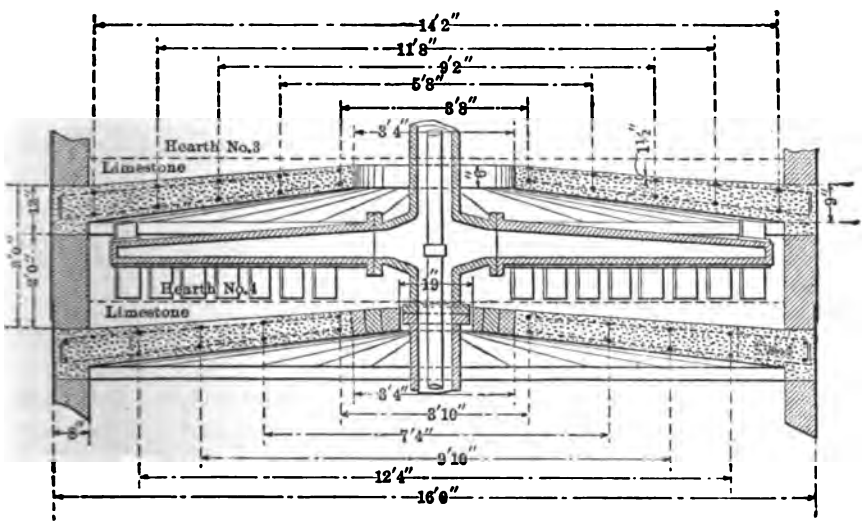


FIG. 7.—Concrete hearth for MacDougall furnace.

The largest installation of Herreshoff furnaces is at Edgewater, N. J. where there are eighteen. At the works of the Arizona Copper Co., California, are eight 21 1/2-ft. roasters and at the Calumet and Arizona plant, at Douglas, Arizona, are twelve 21 1/2-ft. ones.

Concrete Hearths for the MacDougall Roasters.[1]—As suggested by Frank R. Corwin, hearths Nos. 2, 3, 4 and 5 of No. 6 roaster at the Great Falls plant of the Anaconda Copper Co. have been constructed of reinforced concrete instead of brick, formerly everywhere used. Fig. 7 shows the method of construction.

Hearths Nos. 3 and 4 were put in in July, 1912, the others in November of the same year. At the present date (Dec., 1913) the furnace has been in continuous operation, and the hearths are in good condition and

[1] *Trans. A. I. M. E.*, XLVI, 1425.

apparently indestructable. Incrustations are more easily removed than from the rougher brick surface.

Furnace Reactions and Products

Results of the Operation of the Great Falls Flue System.[1]—The new flue system has been in nearly continuous operation since June, 1909, to the present date. The quantity and analysis of the flue dust recovered is given in Table V herewith:

TABLE V.—QUANTITY AND ANALYSES OF FLUE DUST.

Name of Flue.	Tons Dust.		Cu Per Cent.	Ag Oz. per Ton.	Au Oz. per Ton.	Insol.	SiO_2	FeO	Al_2O_3	CaO	S
	Total for 41 Mo.	Average per Mo.									
Blast furnace...	87,020	2,122	8.08	2.7	0.019	34.7	26.8	33.0	7.1	1.7	16.1
MacDougall furnace.....	18,741	457	10.22	3.6	0.023	37.6	29.0	27.1	7.5	0.3	21.3
Uptake and cross-take.....	17,360	423	12.59	4.1	0.026	34.8	26.0	27.2	7.2	0.7	19.5
Main dust-chamber.....	64,048	1,562	8.61	3.3	0.020	33.3	23.6	14.5	8.0	0.7	11.8
Connecting flue[a]	4,000	98	3.09	3.1	0.012	12.6	8.5	5.4	4.0	0.1	10.6
Total.....	191,169	4,662	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] Weight estimated. Average analysis is from sample taken in June, 1912, at different points from dust-chamber to chimney.

When using the old flue system, it was determined that 3.7 per cent. was lost in flue dust from the MacDougall furnaces and 2.57 per cent. from the blast-furnaces. While with the new system practically all the flue dust is recovered, yet the amount of dust produced is about twice that made under the old. This is due to the fact that, as the result of a much stronger draft, there is a greatly increased volume of gases passing per ton of material treated, and again, much fine concentrate is now charged to the blast-furnaces as against none formerly.

In Fig. 8 is shown the plan of the furnaces and of the blast-furnace flue, and a plat of the dust-deposition from end to end of the flue. At hopper 101, the greater amount is doubtless due to flue dust from the uptake.

In Fig. 9 is shown a cumulative plat of the dust as drawn from the main dust-chamber, together with the location of the wire-hung areas. Of the total deposited, 77 per cent. has been removed at the end of the first group of wires, and 1 1/2 per cent. remains after passing the second group. (The question arises whether the second group of wires might not be profitablly omitted, since then an extended area would be left for

[1] *Trans. A. I. M. E.*, LXVI, 1991.

quiet settling L. S. A.) Across the chamber the dust is of the same depth.

A cross-section of a loaded dust-chamber wire shows that the dust is

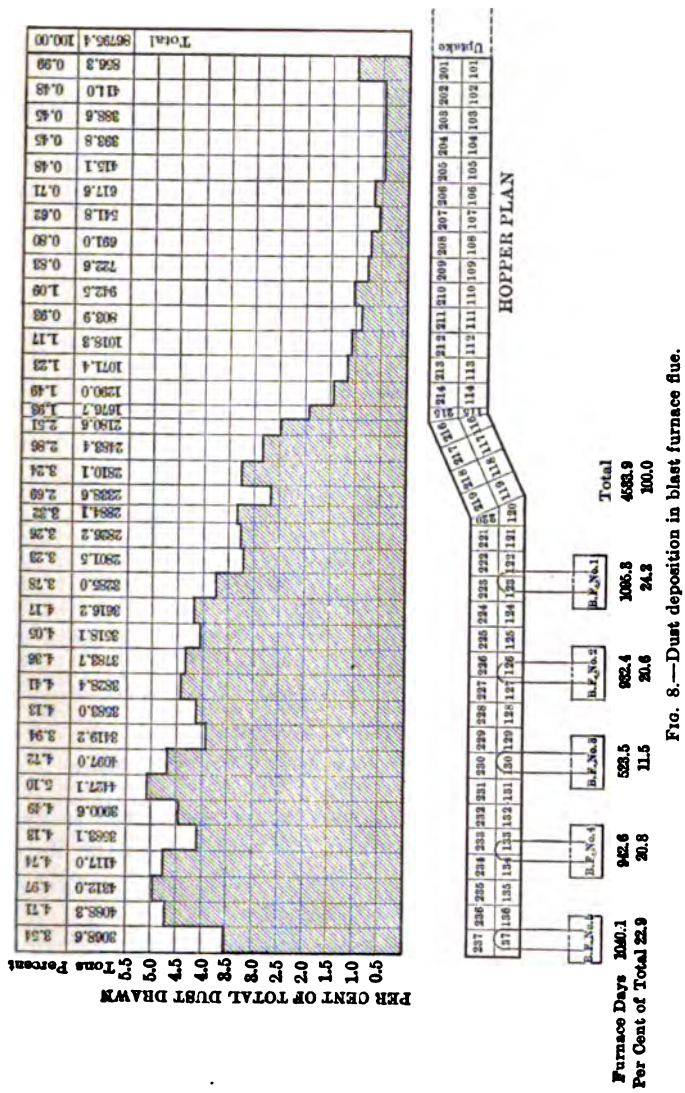


FIG. 8.—Dust deposition in blast furnace flue.

attached in wedge shape, the point of the wedge facing the gas and from edge to back 1 to 2 in. by 3/8 thick; this thins off to 1/4 in. on shaking.

Tests made during March and April, 1911, give the results shown in

Table VI. Tests A, B and C aggregate 39,330 lb. of gas per minute, which compares to within 3 per cent. with the 38,190 lb. in the cross-take (D_1). Tests D_1 and E_1 at the inlet and outlet ends of the main chamber respectively having been taken on different days cannot be compared. Tests D_2 and E_2, however, taken under the same conditions, show 38,700 lb. entering the main dust-chamber as against 42,270 lb. leaving the same,

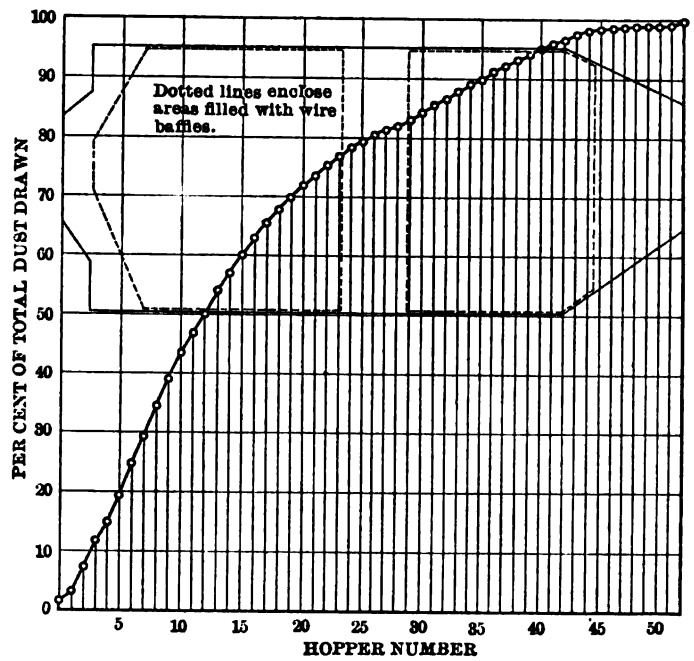


FIG. 9.—Cumulative plot of dust drawn from dust chamber.

the difference 3570 lb. or 9.2 per cent. representing the leakage of air into the chamber. Mixing this air at 54° with the 38,700 lb. of gas at 322° F. we obtain a temperature of 299°. Since the escaping gases are 290°, we find a loss of 9° F., due to radiation.

Based on the amounts of gas in the various flues as shown in Table VI, we have in Table VII, the volume and weight of gases per ton of charge, viz:

The large volume of gases is, in the case of the blast-furnaces, largely due to the entrance of air through the feed-doors. Calculation shows that the roaster gases carry 4.4 per cent. sulphur. Much free air enters at the converter hood since of the 1970 lb., but 10,000 cu. ft., or 446 lb. passes through the converter per minute. The large amount of 55,500 lb., registered at the reverberatory flue, is due to excessive leakage.

Based on the gas volumes given in Table VI and VII, the velocities of the draft through the various flues are as follows:

Blast-furnace flue 17.3 ft. per second; MacDougall furnace flue 17.5; cross-take flue 21.8; main dust-chamber 4.0; connecting flue near chimney 21.0; chimney 10 ft. per second.

TABLE VI.—VELOCITIES, VOLUMES, AVERAGE TEMPERATURES AND WEIGHTS OF GASES.

Location See Plate XIII.	Date, 1911.	No. and Kind of Furnaces.	Average Temperature F.°	Clear Area of Flue Sq. Ft.	Vel. in Ft. per Sec.	Vol. at Observed Temperature Cu. Ft. per Min.	Pounds Gas per Min.	Pounds Gas per Furnace per Min.
A	Apr. 6–8.....	4 B. F....	345	401.6	17.26	415,960	18,510	4,630
B	Apr. 6–8.....	10 MacD.	352	169.0	17.50	253,500	10,980	1,100
C	Apr. 6–8.....	5 Conv.	303	78.5	50.37	213,630	9,840	1,970
G	Mch. 21–24....	2 Rev.	496	152.5	43.34	396,700	14,530	7,270
D_1	Apr. 6–8....	4 B. F. 10 MacD. 5 Conv.	331	636	21.80	859,300	38,190	.....
E_1	Mch. 21–24..	4 B. F. 6 MacD. 5 Conv.	286	977	15.51	901,400	42,280	.....
F	Mch. 21–24..	4 B. F. 6 MacD. 5 Conv. 2 Rev.	311	977	21.03	1,234,900	56,110	.....
E_2	Apr. 10.....	4 B. F. 10 MacD. 5 Conv.	290	977	15.54	910,950	42,270	.....
D_2	Apr. 10.....	4 B. F. 10 MacD. 5 Conv.	322	636	22.74	867,760	38,700	.....

TABLE VII.—AMOUNT OF GAS PER FURNACE AND PER TON OF CHARGE.

Kind of Furnace.	Observed Temperature Corresponding to Given Volume F.°	Rate per Min.		Rate per 24 Hours.		Average Tons Charged.	Per Ton of Charge.	
		Cu. Ft.	Lb.	Cu. Ft.	Lb.		Cu. Ft.	Lb.
Blast.....	345	103,990	4,630	149,745,600	6,667,200	[a]391.6	384,900	17,000
MacDougall...	352	25,350	1,100	36,504,000	1,584,000	[b]70.7	516,300	22,400
Converter.....	303	42,730	1,970	61,531,200	2,836,800	32.0	1,922,900	88,600
Reverberatory	496	198,350	7,270	285,624,000	10,468,800	188.5	1,515,200	55,500

[a] Includes flux but does not include fuel.
[b] Tons copper produced per converter day.

To determine the total volume of the escaping gases, the percentage, and analysis of the contained dust, samples were taken at lower and upper points of the east and west branches of the connecting flue, near the stack (see Fig. 17), the results being shown in Table VIII.

TABLE VIII.

Sample Point	Main Flue Gases.		Average Cu. Ft. of Sample Stand. Cond.	Average Solids Collected Grams.	Calculated Solid Contents of All Flue Gases per 24 Hours.			
	Velocity Ft. per Second.	Cu. Ft. per 24 Hours Stand. Cond.			Solid Matter, Lb.	Cu, Lb.	Ag, Oz.	Au, Oz.
Upper E	18.63	901,816,800	180.4	4.566	51,220	311	.....	.....
Lower E	19.34	960,591,840	184.4	4.225	48,630	347	.....	.....
Upper W	18.63	901,816,800	170.8	4.672	54,900	358	.....	.....
Lower W	19.34	960,591,840	183.6	4.174	48,010	373	.....	.....
Average	18.98	931,204,320	179.8	4.409	50,690	347	28.51	0.202

The amount of new cupriferous material charged to the furnaces in the 24 hours of this test contained 181,220 lb. of copper; the loss of copper was therefore 0.19 per cent. The average sample of the collected solids shows:

Free H_2SO_4, 22.23 per cent.; SiO_2, 2.3; Cu, 0.7; Fe_2O_3 and Al_2O_3, 7.08; S, 6.67; Sb_2O_3, 1.47; Bi_2O_3, 0.81; PbO, 0.49; CaO, 0.18; Zn, 3.31; oxygen to combine with sulphur 10.23 per cent.

Calculations, based upon the material drawn from the flue system and estimates of that in the connecting flue and escaping gases, are presented in Table IX.

TABLE IX.—PERCENTAGE DISTRIBUTION OF MATERIAL IN FLUE SYSTEM.

	Weight.	Copper.	SiO_2.
Blast-furnace flue	39.3	41.4	47.3
MacDougall furnace flue	8.5	11.3	11.0
Cross-take flue	7.8	12.9	8.8
Main dust-chamber	28.9	32.5	30.7
Connecting flue	1.8	0.7	0.7
Stack discharge	13.7	1.2	1.5
Totals	100.0	100.0	100.0

The table indicates, that with a recovery of 98.1 per cent. of the copper, the flue system has got rid of 15.5 per cent. of the finest portion of the dust.

To recover the arsenic contained in the upper part of the main flue-chamber, a plant has been installed, capable of handling about 20 tons daily. To increase the quantity of recoverable arsenic it is proposed to admit air by the twenty-two air-pipes, which have been put in between the two groups of wires in the main dust-chamber. (One can but think this will only increase the eddy currents already due to the presence of those pipes, so that even with increased production of arsenic, settling of the dust would be less complete. L. S. A.)

As justifying the expenditure of $1,100,000 for this flue system, it

must be remembered that the complete recovery of the flue dust was not the only end in view. It was desired, first; to discharge the smoke at so high a point as to harmlessly disperse it; second to make a draft sufficiently strong to remove thoroughly all the furnace gases as they were formed; and thirdly, to remove the flue dust readily and inexpensively.

Bag-house System of the Kennett Smeltery.—The plant and bag-house are described in MINERAL INDUSTRY, XVII, 252; XX, 222. Further details, given by Nelson Navius,[1] are as follows: The flue dust, a whitish powder, weighs 13 lb. to the cubic foot, and has the composition; Cu, 1.04 per cent.; Insol., 7.8; Fe, 6.2; CaO, 1.8; Pb, 7.0; As, 4.3; ZnO, 4.8; $ZnSO_4$, 47.2 per cent., together with Au, 0.03 oz. and Ag, 4.08 oz. per ton.

Cold air is blown into the top of the "distributing chamber" (see MINERAL INDUSTRY, XX, 224) through twelve 2-ft. pipes branching from a main supply pipe above the chamber supplied by a special fan. The temperature of the gases entering the chamber is 130° C., and by the addition of the cold air, this is reduced to the desired temperature of 93° C. (200° F.). The cold air has also the effect of diluting the gas, so that it will contain less than 0.75 per cent. SO_2, as required by law. At the "fan-house" at the end of the "main flue" the gas temperature is 280° C.

The bag-house, 220 ft. long, is divided transversely into five bays with four divisions to each bay, each with a steel hopper for the removal of the dust. The 3000 bags are of wool, 18 in. in diameter by 34 1/2 ft. long. From time to time these are vertically shaken, using the Benedict apparatus which is operated by means of a motor. From the steel hopper of each division, the dust is withdrawn into a wooden trough containing water, so that the flue dust is thoroughly wet down before removal. Air, admitted at the sides and roof of the bag-house, further dilutes the fumes.

The volume of gases passing the fans at the fan-house may be given at 333,000 cu. ft. per minute and in cold winter weather, 22,000 cu. ft. of cold air, introduced at the distributing chamber, cools this to 200° F. In summer as high as 125,000 cu. ft. may be used. Based on the nominal dimensions of the bags, the volume of gas (not counting the cold air admitted) is 0.684 cu. ft. per square foot of bag surface per minute. The amount of dust collected per 24 hours is 12 to 15 tons.

Tests are made every 2 hours for acidity to ensure that no SO_3 is escaping, and to be sure that the gases carry less than 0.75 per cent. SO_2. Actually, this varies from 0.4 to 0.6 per cent. by volume. The bags cost $6 each and their life is from 18 to 24 months.

[1] *Min. Sci. Pr.*, CVI, 374.

Flue-dust Losses at the Copper Queen Smeltery.[1]—By the employment of reverberatory furnaces for the treatment of the finer ore, the flue dust produced by the blast-furnaces has been decreased from 227 tons per day in the first half of 1912 to an average of 116 tons daily. Some 2 tons daily of coarse particles are caught in the converter flue, but this is independent of the finer material, which settles at the brick header at the base of the stack. This coarser portion in the flue has the following composition: Cu, 60.9 per cent.; SiO_2, 2.2; Fe, 8; S, 11.6 per cent.; also Au, 0.115 and Ag, 15.4 oz. per ton.

Connected with the reverberatory furnaces is a dust-chamber of 1200 ft. cross-section by 132 ft. long, hung with 30,000 Rösing wires. From this chamber, during 13 months, has been recovered only 9 tons of flue dust. Most of the dust from the furnaces settles in the waste-heat boilers and flues.

The dust-chamber of the MacDougall plant is of 1370 ft. cross-section by 144 ft. long and has 42,000 wires hanging from the roof. The flue-dust recovery is 6 per cent. of the charge roasted.

Electric Smelting

Smelting in the Electric Furnace.[2]—Dorsey A. Lyon and Robert M. Keeney discuss the question of the smelting of copper ores in the electric furnace as compared with regular blast-furnace smelting, and give drawings of shaft-furnaces to be used in this connection.

They consider that there is a field for the employment of the electric furnace: (1) In regions where fuel is costly and where hydro-electric power is cheap, as in Chili, Canada, in certain parts of the United States and in Mexico. (2) In districts remote from the railroad, where the ore is of a grade too low to stand transportation, and must be concentrated on the spot to blister-copper, and where also hydro-electric power is cheap.

While no electric smelting has been attempted in America, some experimental work has been conducted at the Ilen Smelting Works, Trondhjen, Norway, and some 25 tons of pure copper have been exported.

Three classes of ores have to be considered in smelting, *viz.*, (1) native copper ores, (2) oxide and carbonate ores, (3) sulphide ores.

(1) Native copper ores. Fifteen experiments were made in smelting fine Michigan copper concentrates of grades Nos. 3 and 4, of the analyses given.

[1] *Trans. Inst. Min. Met., Bull.* 110, 28; Mineral Industry, XXI, 256.
[2] *Trans. A. I. M. E.*, XLVI, 2117; *Trans. Am., Electrochem. Soc.*, XXIV (1913); *Min. Sci. Pr.*, CVII, 686, 974.

	No. 3 Per cent.	No. 4 Per cent.
Cu	37.35	25.35
SiO_2	33.33	35.92
FeO	15.40	21.60
Al_2O_3	8.78	12.40
CaO	5.18	5.98
MgO	1.09	1.09
S	0.056	0.096
Fe (metallic)	0.30	0.50
Fines passing a 60-mesh screen	69.73	88.12

There was employed a Siemen's resistance electric furnace of 50 k.w. capacity, smelting a charge of concentrate 22 lb. and hematite 1.1 lb., yielding black copper of 98.59 per cent. Cu and a slag containing SiO_2, 44.88 per cent.; CaO, 6.92; MgO, 2.32; FeO, 29.80; Al_2O_3, 15.34; and Cu, 0.15 per cent.

It may be concluded, that with a furnace operating at a low temperature on a more easily fused mono-silicate slag of 35 per cent. SiO_2 (whether using limestone or iron ore as a flux) the reduction of iron should not bring the black copper below 95 per cent. Cu; the loss by volatilization should not exceed 1.0 per cent. of the copper charged, and the slags should not contain more than 0.25 per cent. Cu. The electric furnace can, however, smelt a siliceous charge of high melting point, but then the volatilization loss is large. The electrode consumption should not exceed 10 lb. nor should there be needed more than 640 k.w.h. per ton of ore or concentrate charged.

The furnace proposed consists of a crucible 14 1/2 ft. diameteriby 9 ft. high, surmounted by a shaft 18 in. diameter by 18 1/2 ft. high. Through the roof of the crucible are suspended vertically three carbon electrodes, one of which is shown.

It is estimated that this 750-K.W. furnace would treat in 24 hours about 23 tons of native-copper concentrate or 25 to 40 per cent. Cu. The furnace would be operated by a 3-phase current of 50 to 100 volts. Experimenting with concentrate as high as 37 per cent. Cu, no short-circuiting was feared. The calculated cost of operation at $43.80 per kilowatt year is $7.18 per ton of 35 per cent. copper concentrate, as against a figure of $8.64 per ton by the regular method, this latter cost including all except amortization. (See MINERAL INDUSTRY, XVIII, 225, for actual detailed costs at the Lake Superior Smelting Works. L. S. A.)

(2) Oxide and Carbonate Ores.[1]—M. Stephan of the Girod Electric Steel Works, Ugine, France, presents the result of an experiment on copper ore from the Belgian Congo, the copper varying from 21 to 6

[1] *Metall u. Erz*, Oct., 1912.

per cent. and iron from 4 to 16 per cent. Charcoal was mixed with the ore for its reduction. An electric furnace of the Girod type was used.

A slag was produced containing SiO_2, 51.9; Al_2O_3, 11.3; CaO,16.8; MgO, 13.7; Fe_2O_3, 3.5; MnO, 0.9; CaO, 0.9 and Cu, 0.46 per cent. The measured temperatures show that melting begins at 1250°. The pig copper in six different runs varied from 65 to 95 per cent. Cu, from 1 to 21 per cent. Fe, and from 1 to 11 per cent. cobalt. The lower the smelting temperature the purer the black copper, but on the other hand the slag would not be so free from copper. With these infusible slags 900 to 1100 k.w.h. was needed per ton of ore, but it is computed that 500 k.w.h. should be enough when making an easily fused slag. The electrode consumption was 16 lb. per ton. The charcoal used was 25 per cent. of the copper in the charge.

(3) Sulphide Ores.—Twenty experiments were conducted at the Bureau of Mines with the Siemens 50-k.w. electric furnace, that was used in the experiments upon native copper. A typical charge was 8.8 lb. of pyrite, 13.2 lb. of nodular roasted ore, carrying Fe 65 per cent.; 5.76 lb. of silicious ore of SiO_2, 75 per cent., and 2.7 lb. limestone. There resulted a matte containing 1.22 per cent. copper, and a slag, with SiO_2, 35.25 per cent.; FeO 41.3; CaO and MgO 11.64; S 3.66 and with but 0.05 per cent. Cu. Thus the sulphur percentage is remarkably high and the copper extraordinarily low.[1]

Besides the first equivalent of sulphur a further 10 per cent. is volatilized or 60 per cent. of all. The copper present in the matte (1.22 per cent.) was enough to ensure the collection of the gold and silver. It was found that 480 k.w.h. was needed, and that the electrode consumption did not exceed 5 lb. per ton.

In semi-pyritic, and indeed in pyritic smelting, coke, varying from 10 per cent. of the charge to as little as 0.5 per cent., is added to the charge to supplement the heat furnished by the sulphur of the ores treated. This addition of coke makes less efficient the air entering the furnace to burn the sulphur of the ore. Also the fuel largely burns above the zone of fusion instead of near the hearth where its heat is most needed. Hence may result crucible troubles and "freezing" of the furnace. The advantage of the electric furnace is, therefore, that by omitting the coke and by generating heat in the crucible we attain two objects, (1) more efficient oxidation of the sulphides, (2) a high temperature in the crucible where it is most needed.

[1] W. McA. Johnson (*Trans. A. I. M. E.*, XLVI, 2726) discussing his experiments in the electric furnace treatment of complex zinc ores, carrying copper (and lead) shows that the slags have low copper values, the average of 104 tappings being Cu 0.065 per cent. On an 8-day run, on a charge analysing 0.43 per cent. Cu there was produced a matte of Cu 5.33 per cent. and a slag retaining but 0.05 per cent. Cu. To attain this result is needed (1) a hot fluid slag (2) a quiet settling of the slag aided by the jar due to the pulsation of the alternating current; and (3) the strong reduction in the smelting zone of the furnace.

Coke at $9.00 per ton can be considered equivalent to electric energy at $16.20 per kilowatt year. Taking the consumption of electrodes, as in electric smelting of iron ores, at 5 lb. per ton, this at 6 cents per pound would be 30 cents per ton of ore treated.

F. L. Clerc[1] suggests that an electric current be used for preheating the blast in ordinary smelting, applying an electric heating coil at each of the tuyère pipes.

Blast Furnaces

The Loss of Heat from Blast-furnace Water-jackets.[2]—To determine this heat-loss, in the case of a 36 by 180-in. blast-furnace of the Reduction Department of the Anaconda Copper Mining Co., Great Falls, Mont., R. P. Roberts notes the rise in temperature and the quantity of the escaping water with the following results:

The average heat removed by the nose of the spout was 430, by the spout 2535, by the breast-jacket 610, by the main end-jackets 5400 and by the main side-jackets 4375 pound-calories per minute. Especially in the case of the side-jackets, this quantity varies, according to the crusting of the jackets, from as little as 1265 to as high as 7355 pound-calories per minute.

Taking an average figure of the heat-loss of side- and end-jackets of a furnace 15 ft. long at an approximate average of 31,440 pound-calories, the jacket loss for a 51-ft. furnace would be 76,250, and for an 87-ft. furnace, 121,050 pound-calories.

With the heat-value of blast-furnace coke at 6400 lb. calories, we have an equivalent consumption of coke of 4.91 lb. for the 15-ft. furnace, of 11.91 lb. for the 51-ft. furnace and 18 lb. for the 87-ft. furnace. Estimating that the coke would be equivalent to 10 per cent. of the charge, then, to heat the jacket water, there would be needed for the 15-ft. furnace 1.0 per cent., and for the 87-ft. furnace 0.66 per cent. of coke. Thus we may say, that while such saving is of value, it has been too much emphasized as an advantage of the larger furnace. Computing the saving for furnaces of different lengths, it has been found that for furnaces of more than 60 ft. long, this proportionate heat saving becomes negligible. Expressed in another way, where in a 15-ft. furnace 10 per cent. of the total coke is used in heating the jacket water, this becomes 7.1 per cent. for the 51-ft. and 6.6 per cent. for the 87-ft. furnace.

These theoretical considerations are properly modified if we consider that part of the duty of heating jacket water may be borne by the burning sulphides. In the case of reduction smelting, we must also

[1] *Trans. A. I. M. E.*, XLVI, 2727.

[2] *Trans. A. I. M. E.*, XLI, 1343.

remember that the coke, being imperfectly burned, has an efficiency much less than 6400-lb. calories.

Development of Blast-furnace Construction.[1]—J. A Church gives us a history of the development of the blast-furnace at the Boston & Montana Smeltery, Great Falls, Mont., from the first ones in 1893 of 40 by 120 in., to the one built in 1911, which is 84 by 180 in. at the tuyére level.

In the blast-furnace department of this plant are four furnaces, each 56 by 15 ft. long, and one of 84 by 15 ft. long, the smaller furnaces having a capacity of 450 tons, the large one a capacity of about 600 tons daily.

In summarizing the results of experiments with half-a-dozen different types of furnaces during the period of 20 years, he concludes:

With an increase in the height of the ore-column, and for a given volume of blast, the blast-pressure increases so that it sets a limit to the economic height.

With a high column it takes longer for a corrected charge to come down, also crusts harder to bar off.

On the other hand, a high column with a cool top means better reduction and better fuel saving; with a wide furnace it must be of such height as to ensure an even distribution of the blast.

Increase of width of the furnace increases the hearth-area, and proportionately the tonnage put through. However, increased tonnage calls for increased volume of air, and this demands either higher pressure or increased tuyère area, as shown in the new No. 3 furnace, where the tuyère slots are 11 in. high by 3 in. wide.

Wide furnaces will need effective systems of mechanical charging as compared with the older plan of charging at the side.

Reverberatory Furnaces

Reverberatory Furnace Water-heat Boilers.[2]—S. S. Sorensen discusses the settings for Sterling and for Babcock & Wilcox boilers respectively. In each case the boiler is set 14 ft. from the furnace and at such a height that the furnace off-take flue enters below the tube system.

He finds that for 100 days the repair cost for the Babcock & Wilcox boilers was $189.39, and the time it was down for repairs 8.28 days, as against $100.69 and 6.93 days for the Sterling boilers. On the other hand the water evaporated per day by two boilers of the Babcock & Wilcox type was 861,111 lb. and for two of the Sterling type was 621,472 lb.

[1] *Trans. A. I. M. E.*, XLVI, 1367; Mineral Industry, XXI, 240.
[2] *Min. Sci. Pr.*, CVII, 575.

Reverberatory Furnaces at Great Falls.[1]—This recently consisted of three gas-fired regenerative furnaces, each having a hearth 15 ft. 9 in. by 45 ft. These furnaces will be changed to the direct-fired type with hearths 22 by 102 ft., and will be equipped with hot-blast stoves for heating the secondary air, that is, the air not passing through the grate, but blown in over the bridge wall. For operating the regenerative furnaces there have been employed twenty-six gas producers, which will be abandoned, due to the use of the direct-fired furnaces. These furnaces are now under construction. This first one completed shows novel features. The masonry is built up within a tank of heavy steel plate, each end of the furnace being rounded. The waste gases go to hot-blast stoves where the secondary air is preheated. The buck-staves are spaced farther apart than has been customary, dependence being placed on the plate-tank, and are supported by inclined props set up by jack-screws. Thus, all tie rods are omitted, and it is estimated that $5000 to $6000 is saved, besides the fact that there is a clear space to repair the roof. The side walls are 30 in. thick, the arched roof 20 in. The 43-ft. regenerative furnace, formerly used, cost $50,000 to build; it is estimated that the new 102-ft. one will cost $100,000.

Converters and Converting

Converter Reactions.[2]—Redick R. Moore gives the accompanying table of converter reactions. The predominating reactions in the

TABLE X.—CONVERTER REACTIONS.

		Volatilised.	Gas.	
			SO_2	N
			Per cent.	Per cent.
I.	$5\ FeS + Heat = Fe_5S_4 + S$	S.	.....	.....
II.	$Fe_5S_4 + Cu_2S + 13\ O = 5\ FeO + Cu_2S + 4\ SO_2$	.....	13.90	86.1
III.	$Fe_5S_4 + 14\ O = 2\ FeO + Fe_2O_4 + 4\ SO_2$	.....	13.04	86.9
IV.	$2\ Fe_2O_4 + Cu_2S = 6\ FeO + Cu_2 + SO_2$	.....	100.00	.....
V.	$Fe_2O_4 + Fe_5S_4 = 4\ FeO + 4\ FeS$	S.	.....	.....
VI.	$Fe_5S_4 + 2Cu + 11\ O = 5\ FeO + Cu_2S + 3\ SO_2$	.....	12.52	88.4
VII.	$5\ FeS + 2\ Cu = Fe_5S_4 + Cu_2S$	.....	.....	.....
VIII.	$Cu_2S + 2\ O = 2\ Cu + SO_2$	.....	20.8	79.2
IX.	$4\ Cu_2S + 9\ O = 6\ Cu + Cu_2O + 4\ SO_2$	.....	18.52	81.4
X.	$Cu_2O + Fe_5S_4 + 12\ O = 2\ Cu + 5\ FeO + 4\ SO_2$	.....	14.90	85.1
XI.	$2\ Cu_2O + Cu_2S = 6\ Cu + SO_2$	.....	100.00	.....
XII.	$2\ Cu + O = Cu_2O$	.....	.....	100.0
XIII.	$Fe + O = FeO$	.....	.....	100.0
XIV.	$Cu_2S + H_2O = Cu_2O + H_2S$	.....	.....	.....
XV.	$FeS + H_2O = FeO + H_2S$	.....	.....	.....
XVI.	$2\ H_2S + SO_2 = 2\ H_2O + 3\ S$	S.	.....	.....
XVII.	$3\ ZnS + 6\ O = 2\ ZnO + ZnS + 2\ SO_2$	ZnS	14.90	85.1
XVIII.	$2\ PbS + 3\ O = PbO + PbS + SO_2$	PbS	.....	.....
XIX.	$3\ Fe_4As + 10\ FeS + 43\ O = 22\ FeO + As_2O_3 + 9\ SO_2 + AsS$	AsS	9.80	90.2
XX.	$CaCO_3 + Heat = CaO + CO_2$	.....	.....	.....
XXI.	$2\ Mo + SiO_2 = (Mo)_2\ SiO_2$ (slag)	.....	.....	.....
XXII.	$S + O_2 = SO_2$	.....	20.80	79.2

[1] Mineral Industry, XXI, 248.
[2] *Trans. A. I. M. E.*; Mineral Industry, XVI, 362.

first or slagging period are II and III of the table, the subsidiary reactions of the same period are expressed by reactions, I, IV, V, VI, VII, X, XIII, XV and XXI. In the second period, that of the conversion of white-metal to copper, the predominating reactions are VIII and IX, while the simultaneous subsidiary reactions are expressed by XI, XII, XIV, XVI and XVIII.

During the first period the average gases should contain between 13.0 and 13.9 per cent. SO_2, and during the second period 19 to 20.8 per cent. These gases contain free volatilized sulphur (I and XVI), ZnS (XVII), PbS (XVIII) and AsS (XIX), as has been qualitatively determined by Redick; and this is an evidence of the complete utilization of the oxygen of the blast. He also asserts that there is no SO_3 in converter gases, while CO_2 should be negligible.

Efficiency of the Air and Speed of Converting.[1]—Herbert Haas, in discussing the rate of oxidation or speed of converting, makes the following estimate of the air needed at 100 per cent. efficiency. By forcing into the converter 440 lb. of oxygen, equal to 1914 lb. of 24,000 cu. ft. of air, there will be oxidized 515 lb. of Fe to 660 lb. of FeO, and 293 lb. of S to 586 lb. of SO_2, all from 1172 lb. of 40 per cent. copper matte and this corresponds to 100,000 cu. ft. of air per ton of copper. Compared with this we have an air consumption varying from 126,000 to 260,000 cu. ft., or of efficiencies varying from 80 to 38.5 per cent. respectively, both with acid and basic-lined converters.

At the Garfield plant of the American Securities Co., using Pierce-Smith converters, the air efficiency is reported as varying from 77 to 80 per cent. Wheeler and Krejci's experiments[2] show that while as much as 22,000 cu. ft. of air per minute can be used on the 20 ft. upright Great Falls converter, the best results have been attained with 18,000 cu. ft. at which one can count on an efficiency of at least 94 per cent.

E. H. Hamilton some years ago found the oxygen content of the escaping converter gases in acid converting to be as follows:

First half of the first blow	0.1 per cent.
Second half of the first blow	1.0 per cent.
First half of the second blow	9.0 per cent.
Second half of the second blow	17.0 per cent.

This clearly shows why the actual consumption of air so largely exceeds the theoretical.

The Upright Basic Converter.[3]—A. E. Wheeler and M. W. Krejci, of the Boston & Montana Reduction Works, Great Falls Mont., in a paper entitled "Great Falls Converter Practice," trace the development

[1] *Trans. A. I. M. E.*, XLVI, 2647, 2664; MINERAL INDUSTRY, XX, 221.
[2] *Trans. A. I. M. E.*, XLVI, 1831.
[3] *Trans. A. I. M. E.*, XLVI, 1831; *Eng. Min. Jour.*, XLV, 901.

of acid-converting from the year 1892, and of basic-converting from 1911 to 1913 inclusive. Table XI gives the record of performance of two types of upright, side-blown, basic-lined converters operated during this period.

Classes III and IV are 12 ft. diameter, Class V is 20 ft. diameter of the shell.

Figs. 10 and 11 show in plan and elevation the class IV or 12-ft. converter, used also at the smeltery of the Cananea Consolidated Copper Co., and the Arizona Copper Co.

Figs. 12, 13 and 14 show three sections of the No. V or 20-ft. converter. It is of 250 tons daily capacity. The converter proper, not including bearings and gears, weighs 65 tons, and will take a 50-ton charge. It is operated by a 100-h.p., Westinghouse type, M. C. direct-current motor.

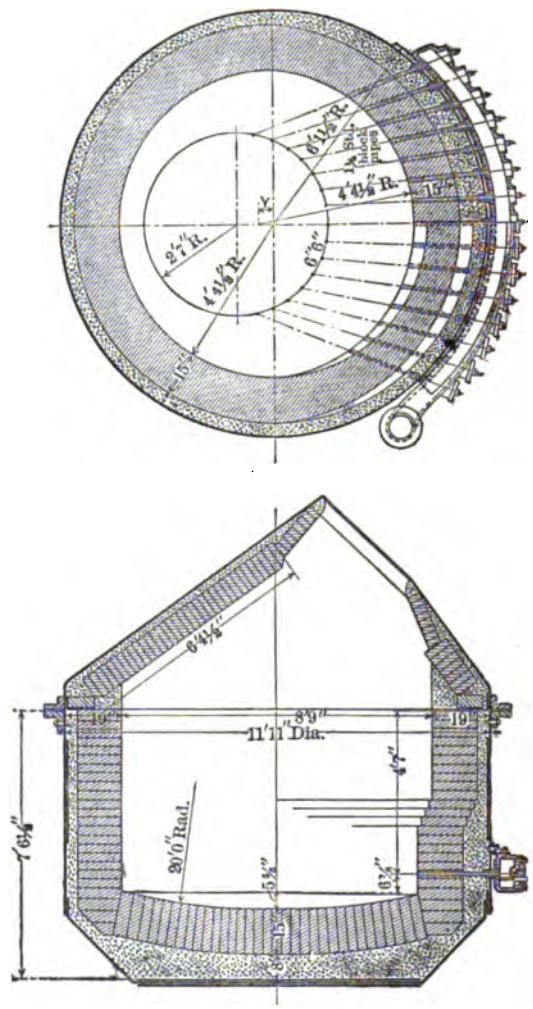
The first converters, electrically driven, were equipped with direct-current motors, but a satisfactory alternating-current motor has now been developed. The approved practice is to gear the motor to a jack-shaft, which in turn, through a worm-gear, drives the large gear on the converter proper. This prevents slipping and the chance of the overbalanced converter moving past the desired position. The electric brake is also so designed that

TABLE XI.—RECORD OF BASIC-LINED CONVERTERS.

Converter.		Campaign.		Elapsed Days.	Tons Cu.	Charges.	Tons Cu Per Charge.	Total Time Operating.		Tons Cu Per Converter-Hour.	Tuyères.	
Class.	Bottom.	From	To					Hr.	Min.		No.	Approx. Internal Diam., In.
IV	B	Mar. 9, 1911	June 3, 1912	451	12,216.1	1,026.0	11.9	7,509	45	1.63	15	1.25
IV	C	Apr. 29, 1911	Jan. 4, 1912	251	7,479.1	580.0	12.9	4,149	40	1.80	15	1.25
aIV	D	May 7, 1911	Dec. 22, 1912	596	13,414.0	1,014.0	13.2	7,663	55	1.75	15	1.25
bIV	A	June 22, 1911	June 1, 1913	710	16,407.3	1,170.0	24.2	8,198	40	2.00	26	1.25
cIII	3	Nov. 16, 1911	Dec. 25, 1912	406	8,990.7	640.0	14.0	4,523	50	1.99	24	1.25
IV	C	Mar. 17, 1912	Apr. 13, 1913	392	5,843.0	445.0	12.7	2,960	10	1.91	34	1.25
V	A	Aug. 3, 1912	Dec. 17, 1912	137	2,835.0	88[illegible]	32.4	656	45	4.31	62	1.75
bIV	B	Sept. 12, 1912	June 1, 1913	.....	3,904.3	307.0	12.7	2,180	20	1.79	26	1.375
aIV	D	Dec. 28, 1912	Apr. 2, 1913	.....	968.2	85.0	11.4	601	45	1.69	7	2.75
bV	A	Jan. 20, 1913	June 1, 1913	132	6,223.2	169.9	36.6	1,306	0	4.77	26	2.25
cIII	3	Mar. 28, 1913	June 1, 1913b	70	404.2	33.0	12.3	251	50	1.60	11	2.25
aIV	D	May 12, 1913	June 1, 1913	20	369.3	28.0	13.2	184	0	2.01	15	2.25

a These three runs are really parts of the same campaign.
b Still running on this campaign.
c These two runs are really parts of the same campaign. The converter was shut down on Dec. 25, 1912, to change the tuyères for experimental purposes.

it is applied when current is shut off, so as to hold the converter in fixed position. Motors may be totally inclosed, or they may be set alongside the converter in a sheet-iron housing. They should be of substantial construction, as in steel mills, should have a high overload



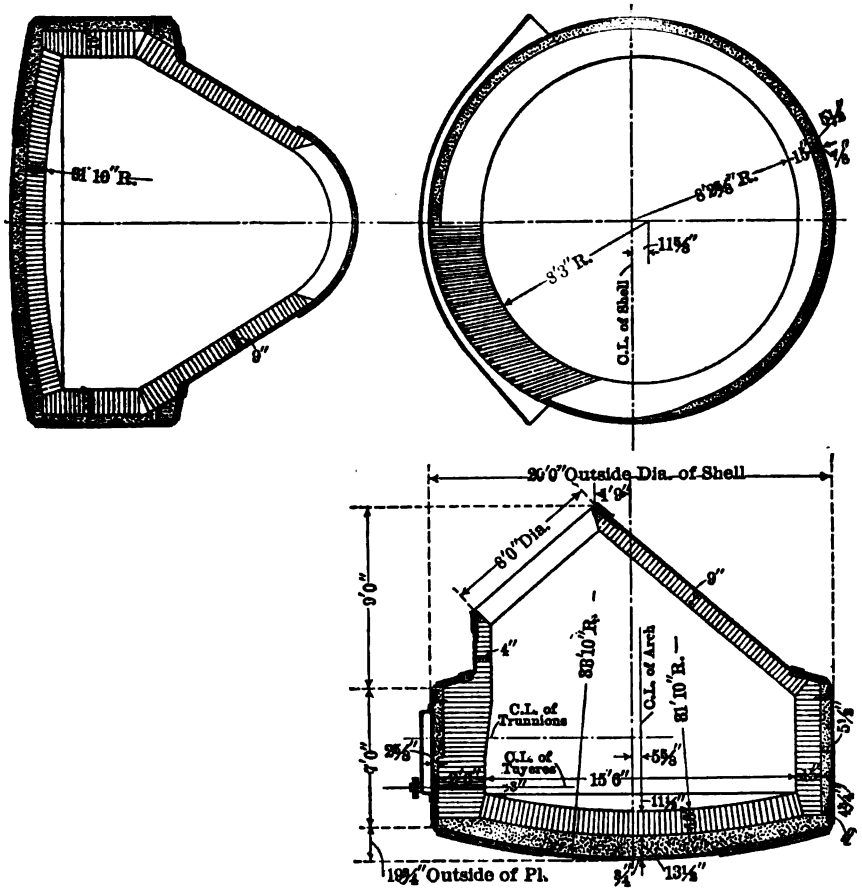
FIGS. 10 AND 11.—Twelve-foot basic converter.

capacity, and be built to withstand a high temperature, such as from a splash of molten metal.

As compared with hydraulic operation, the chief advantage of the motor, is a smooth motion. The converter starts gently without halt or jar, and thus is eliminated the chance of splashing.

We may here add that it is desirable to equip the travelling crane with the same type of motor. These are subjected to dust, fumes and heat, and should be substantial. Also with identical motors fewer spare parts are needed.

The following table gives the operating labor costs for the 12-ft. and the 20-ft. converters respectively.



FIGS. 12 TO 14.—Twenty-foot basic converter.

Since the output of the 20-ft. is two and one-half times that of the 12-ft. converter, the labor costs become for one large converter $42, for three smaller ones $57.25 per pound of copper or 0.019 and 0.026 cents respectively.

Summarizing results we find that the best practice calls for the basic-lined, rather than for the acid-lined converter.

TABLE XII.

Labor.	Rate per Shift.	12-ft. Converter.				20-ft. Converter.			
		Per Shift.		Per Day.		Per Shift.		Per Day.	
		No.	Cost.	No.	Cost.	No.	Cost.	No.	Cost.
Skimmer	$4.25	1	$4.25	3	$12.75	1	$4.25	3	$12.75
Helper	3.25	1	3.25	3	9.75	2	6.50	6	29.25
Total		2	$7.50	6	$22.50	3	$10.75	9	$42.00

A large converter is better than a small one, and the size is limited only by mechanical considerations. Even the largest plants should have a few. The 20-ft. converter can be used for the storage of matte or of finished copper for long periods, if the mouth is properly covered. Therefore, in a plant of comparatively small production, a combination of ample matte-storage capacity in the blast-furnace settlers and reverberatory furnaces, together with a large converter, can be made so as to allow all converting to be done on one shift, and the casting of the copper to be on the next shift.

The best sized tuyère is 2 1/4 in. internal diameter. Smaller ones tend to weaken the lining, pass less air, and add to the work of punching. Those of 2 3/4 in. diameter have not proved successful.

The 8-ft. mouth for the converter has been found satisfactory. If smaller, it crusts up more rapidly; on the other hand it may be so large as to permit too free an escape of the heated gases.

At least 5 in. should be allowed between the tuyères and the bottom lining, and this dimension can be increased, provided there is copper enough at the finish to cover the tuyères.

The total height of 17 ft. 7 3/4 in. has been found satisfactory for the large converter; trials of a taller one were not so. The dimensions to consider should rather be the distance from the center line of the tuyères to the lowest point of the mouth.

Tuyères made of cast copper have been tried. They stand fairly well while blowing from matte to white metal, but melt away rapidly when blowing from white metal to copper.

For the successful operation of the basic-lined converter the following points, according to E. P. Mathewson, are of importance:[1] The temperature in the converter should not be permitted to exceed 2100° F. (1150° C.); the tuyère opening should be preferably 1 1/2 in. in diameter; these tuyères should be punched the full size of the opening immediately after pouring copper; the converter should be carried as full of matte

[1] *Trans. A. I. M. E.*, XLVI.

(and slag) as possible in order to prevent sudden changes in temperature and overheating of the lining; and the slag should contain preferably 25 per cent. of silica.

Tests and analyses show that there is no relation between the percentage of silica in the slag and the wear of the basic lining.

Summing up the advantages of basic-lined converters, as compared with those acid-lined, there are: decreased cost of lining; ability to use large units with consequent economies in labor, power and repairs; neatness and cleanness of plant; and, by doing away with the lining department, abolishing the danger due to dust affecting the men engaged in preparing the lining.

When rebuilt, the converter plant at Great Falls will contain three converter stalls for 20-ft. converters. For each ton of blister copper produced, 0.7 tons of raw concentrates is charged. After preliminary drying, much of the concentrates will be smelted through the converters. The converter copper is cast either into anodes for the electrolytic refinery, or into ingots for shipments East, this being done in two electrically-driven casting-machines. The copper is poured into the molds from a ladle, tilted electrically.

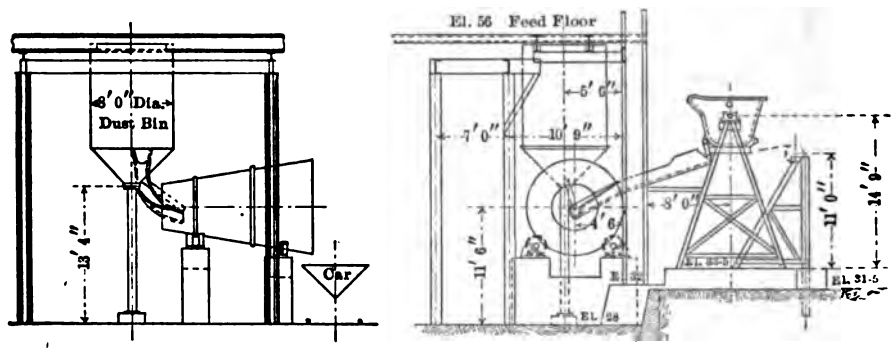
Collar Puller for Converters.—In operating a converter the material is thrown up by the violent agitation of the blast toward the open mouth, where, through cooling, it becomes attached, and gradually builds up a nose or collar, which if allowed to grow, will in time close the mouth. This difficulty is especially marked in the operation of the basic-lined converter since for the maintenance of the lining, a moderate temperature is desirable.

L. O. Howard describes a device[1] suggested by Lee Young, foreman at the Old Dominion Plant, Globe, Arizona. It consists of a bar so hung, that when dropped by the crane through the mouth of the converter, the ends will catch under projecting crusts, which have formed in the operation of the converting. The short cutting end is worked into position, where the bite is to be made, and a pull taken by the crane, thus lifting the long end into contact with the opposite side of the converter, and forcing the short cutting end into the collar. A steady pull will draw the tool through the mass until near the top, when the collar breaks and comes away. The cutter easily tears through the heaviest collar without lifting the converter shell from the stand. A bite may be taken at any angle. Fifteen to 20 minutes work per shift is sufficient to keep the shell open to any size required.

Converter Slag and Flue Dust Mixer.[2]—We present two elevations of the apparatus already described in the last number of the MINERAL

[1] *Min. Sci. Pr.*, CVI, 783; MINERAL INDUSTRY, XVI, 365.
[2] *Inst. Min. Met. Bull.*, 110, 23; MINERAL INDUSTRY, XX, 218; XXI, 257.

INDUSTRY. At first a cylinder 4 ft. diameter by 9 ft. long was tried, but a collar crusted at the ends of the cylinder which were difficult to remove. The working of the cone, when substituted, satisfied all expectations, and working three shifts, could easily handle all the converter slag made, and from 60 to 70 tons daily of flue dust. The best and most even product was made with 18 to 20 per cent. of converter slag, and 25 per cent. was the limit for a good coarse product unmixed with flue dust. A maximum was attained of 535 tons, and an average of 325 tons daily. There was needed a 50-h.p. motor, driving the drum 8 r.p.m. When reverberatories were used for melting down the dust, the use of the apparatus was discontinued. Had it, however, been rebuilt, the machine would have been heavier, and the small diameter of the cone increased to 6 ft. to



FIGS. 15 AND 16.—Slag and flue dust mixer.

better dislodge the crust. If the flue dust contains sulphur, much sulphur dioxide gas is liberated, and provision for its removal and for collecting a small amount of flue-dust should be made. Two of these cone-mixers have been installed at the works of the Arizona Copper Co., Clifton, Ariz., intended for mixing fine silicious material with converter slag, and sending the resultant product to the reverberatories, in order to attain a better fluxing of this fine material.

Basic Converter at Globe, Arizona.[1]—L. O. Howard related his experience in the operation of a 12-ft. Great Falls type basic converter.

At first, due to a large charge and consequent high back pressure, the tuyères were at times plugged, or by careless tilting when punching, several were lost, so that, owing to frequent consequent chipping off, it seems that the wear at the tuyère line would be excessive; still, with the production of 14,500,000 lb. of copper, the lining, to the first patching, gave out about 20 in. above the tuyères.

It was estimated that a life of 20,000,000 lb. should be attainable. When 2,000,000 lb. of copper had been produced it was discovered that it

[1] *Trans. A. I. M. E.*, XLVI, 2674.

was possible to coat the brick with magnetic iron oxide, and thus build up a protective lining. At one time this coating was as much as 15 in. thick upon the brick, but this so lessened the capacity that it was taken off and a thinner one substituted. The great difficulty is in making the men keep the temperature down, since a short run at a high heat will clean off the coating and expose the underlying brick. It was, however, possible with care to maintain the coating for as much as six weeks at a time without any brick showing, though it is impossible to always do so. When too thick at the tuyères, punching is difficult. The original thickness at the tuyères region was 30 in. and this was gradually corroded to 10 in. until the first patching.

The shell was in continuous use for 173 days, and made 664 charges of 11 tons copper per charge or 42 tons per day, the matte averaging 43.9 per cent. copper. The highest record was 66.4 tons per day with a 52-per cent. copper matte, and 60 tons per day for three days with a matte of 47.7 per cent.

The Small Basic Converter.[1]—Those installed at Gatica, Chile, in 1912 are described by Bancroft Gore. They are 58 in. in diameter by 84 in. long, hand-tilted, with the mouth 28 in. diameter and have 13 one-inch tuyères, spaced 4 in. center to center, and in operation, an inside length of 64 in. One layer of No. 1 arch brick was used throughout, except for 12 in. above and below the tuyères which had two layers of straight bricks. These brick were cemented fast to the shell by a thick layer of sodium silicate and finely ground dead-burned magnesite. No provision was needed for the expansion of the brick. In operation a protective coating of about 6 in. of highly refractory slag (containing CuO 6.4 per cent.; FeO 78.5; SiO_2, 5; CaO 1.8; Al_2O_3, 3.5 per cent.), formed upon the brick when converting a 45 per cent. copper matte. When the grade of the matte dropped below 44 per cent., the coating would gradually disappear, exposing the brick to corrosion, unless the matte could be again raised to near 50 per cent., when the coating would again rapidly form; then the matte could be dropped from 47 to 44 per cent.

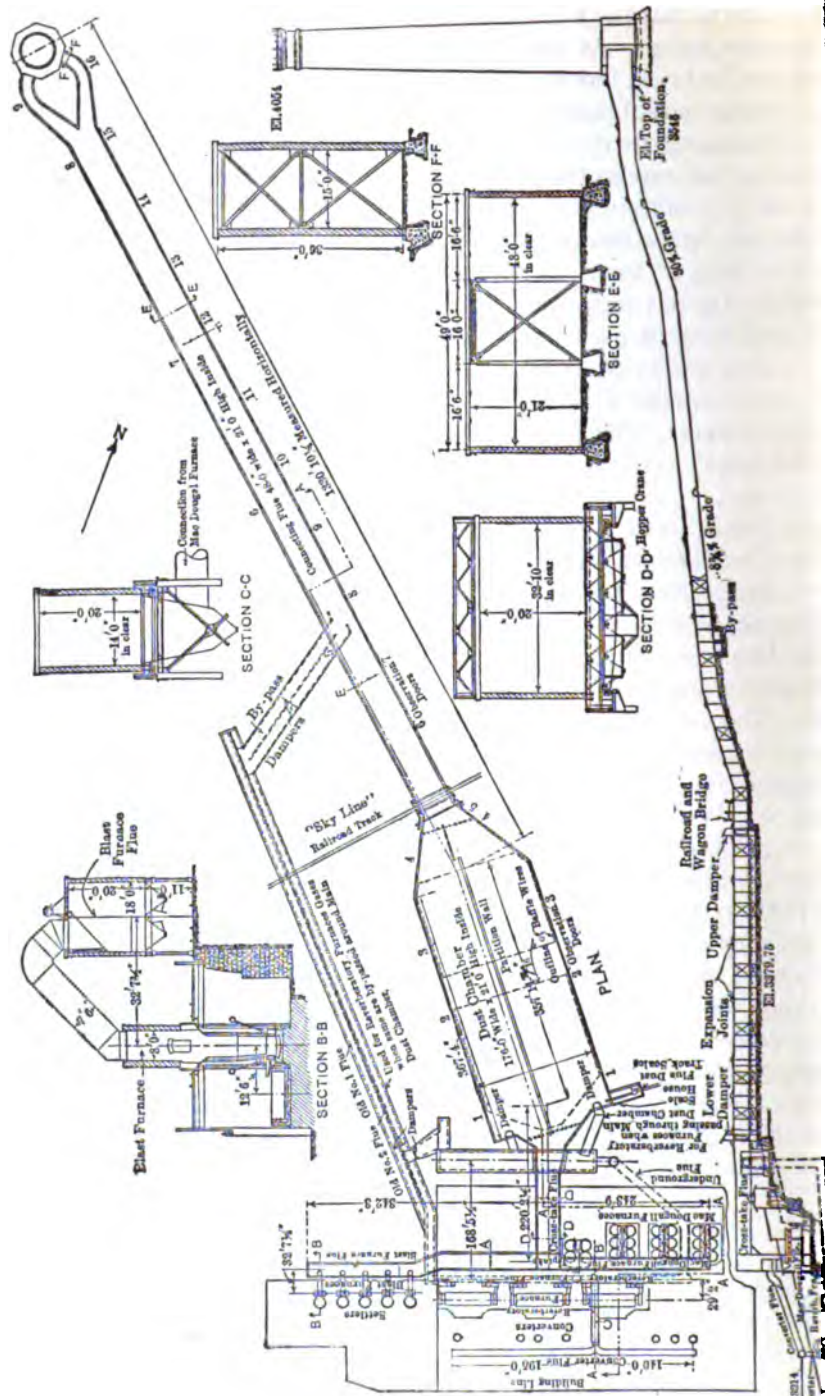
Normally, the converters would take 6000 lb. of matte in two charges, yielding from this some 2500 lb. of copper. With the slag coating gone and the bricks exposed, the converter would take as high as 22,000 lb. of matte in three charges and yield 8000 lb. of copper.

The magnesite brick, laid down, cost 25 cents each.

Smelteries

The Great Falls Smeltery of the Anaconda Copper Mining Co.[2]—In a paper entitled "The Great Falls System and Chimney," C. W. Goodale

[1] *Trans. A. I. M. E.*, XLVI, 2675.
[2] *Trans. A. I. M. E.*, XLVI, 1396, 1965; Mineral Industry, XV, 250; XVII, 251; XVIII, 193.


PLAN
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
"Sky Line" Railroad Track
Blast Furnace Flue
Blast Furnace
Upper Damper
Lower Damper
Expansion Joints
Railroad and Wagon Bridge
By-pass Dampers
Connection from Mac Dougal Furnace
Dust Chamber Inside
Dust Chamber Outside
Dust Chamber Partition Wall
Flue Dust Screw Conveyor
Flue Dust Storage Bin
Flue Dust Screw Conveyor
Flue Dust Bucket Elevator

and J. W. Klepinger give us details of construction of the smeltery and its flue-system. Figs. 17–23 show in plan and elevation the entire plant, and Figs. 24–27 show the elevation and plan the main dust-chamber. The works treat 3800 tons of ore per day and employ 1100 men.

Referring to Fig. 17, the twenty-two roasters have a common "MacDougall Furnace Flue" shown in elevation at "Section C.C." The flue is 14 by 20 ft. in size, runs 227 ft. to the "uptake" and has a hopper bottom. The tracks under the hoppers of this flue, as under those of the "Blast-furnace Flue," are on the reverberatory-furnace charge-floor level, so that the regular calcine trammer's crew draws and trams the hopper-dust to the reverberatories without extra labor expense.

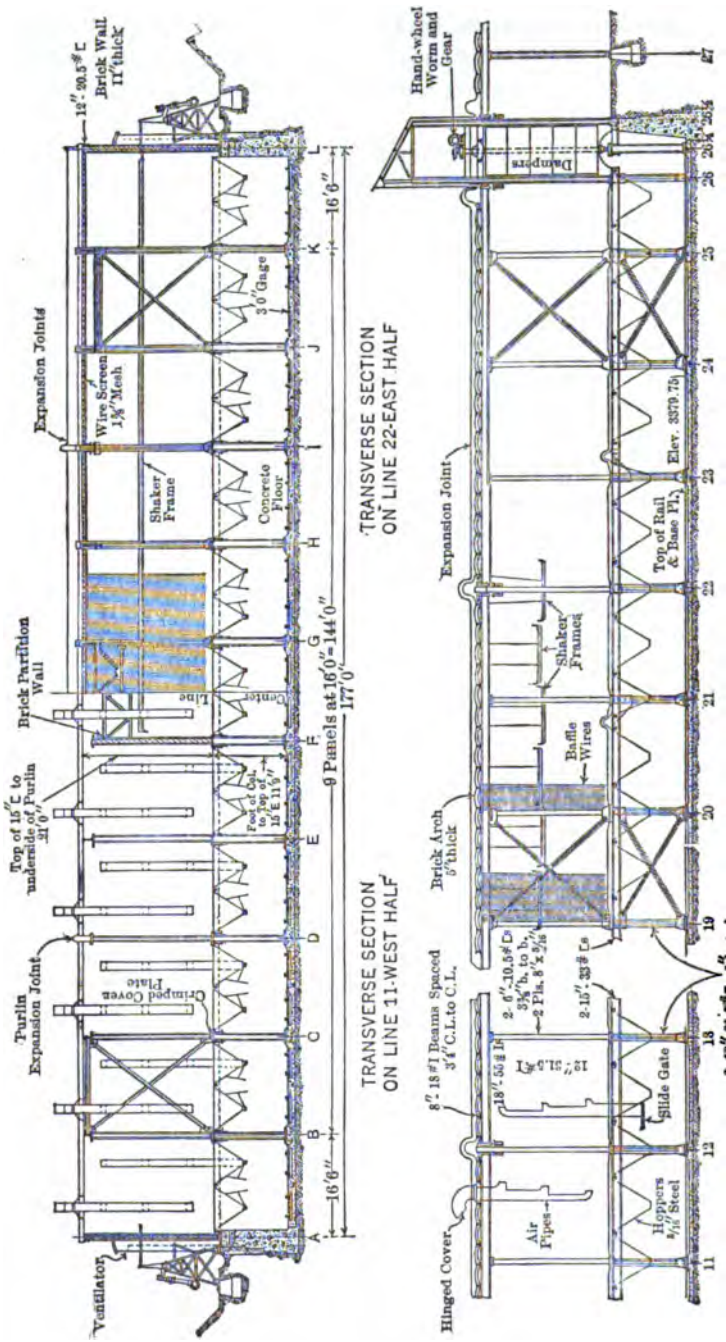
As shown in the general plan and at "Section B.B." the steel goose-neck pipes of the five blast-furnaces connect into the "Blast Furnace Flue." This flue is 18 by 20 ft. in size, and has a bottom of a double row of hoppers. It is 326 ft. long to the "uptake."

There are seven converter stands, blowing into a flue 335 ft. long, which, near its middle, branches into the "MacDougall Furnace Flue." In place of these there will be three 20-ft. upright converters.

The three reverberatory furnaces discharge into the "Reverberatory-furnace Flue," 12 ft. wide by 14 ft. high, which is arranged to deliver generally into the system marked in the plan of Fig. 17. "Old No. 2 Flue, Old No. 1 Flue," and by a "By-pass," to the "Connecting Flue." The gases may, however, go direct to the "Dust Chamber" by a flue branching from the point marked "Old No. 2 Flue," entering the "Dust Chamber" at two points marked in Fig. 27 "Flue for Reverberatory Gas."

Dampers are provided to shut off the current in either direction so that the reverberatory gases may pass around the "Dust Chamber," or through it, as desired. The uptake, which carries the combined converter, MacDougall, and blast-furnace gases, is 32 ft. 10 in. by 20 ft. and 93 ft. 9 in. high from the top of hoppers. The "MacDougall Furnace Flue" enters opposite the "Blast-furnace Flue," but its bottom is 9 ft. above the top of the latter. To prevent baffling, a steel-plate diaphragm is so hung in the uptake as to cause the blast-furnace gases to travel along the bottom of the "Cross-take Flue," while the roaster gases go along above, but soon mix with the other gases.

The "Cross-take Flue," which connects the "Uptake" to the "Dust Chamber," is shown in cross-section at section DD, Fig. 17. It is 32 ft. 10 in. wide by 20 ft. high and has a bottom composed of 100 pyramidal hoppers. From these the dust is drawn off into hoppers carried on a traveling crane beneath, and thereby transferred to chutes leading to the bottom of the uptake flue, then trammed to the reverberatories.



FIGS. 24 TO 26.—Main dust chamber.

The location of the "Main Dust-chamber," 176 ft. wide by 21 ft. high, is shown in Fig. 17, a cross-section and a partial longitudinal section in Figs. 24–26 and a hopper plan in Fig. 27. To allow the gases to freely approach and leave, only the space within the dotted lines (Fig. 27) is hung with the wires. As also indicated on the plan, the wires are hung in two groups or divisions, with a transverse space of 47 ft. of clear flue between them. The groups take up together an average of 317 ft. of the flue. The steel wires are spaced at 2.3 in. center to center, there being 1,200,000 wires, each weighing about 1 lb. In the first group of wires, for a distance of 51 ft., are No. 8 wires 16 ft. long, the rest being No. 10 wires, 20 ft. long. The second group consists of No. 10 wires, 20 ft. long.

In the clear flue between the groups come two rows of pipes, one row from above, one from below, from 11 to 13 of Fig. 27, for the admission of air, in case it is desired to cool the gases with a view of condensing fume. See also Fig. 25 "Transverse Section on Line 1,1, West Half," also " Longitudinal Section."

A longitudinal brick partition on the line of columns marked "*F*," Fig. 17, divides the flue so that there are six panels on the east and five on the west of the partition. At each end of the chamber a line of cast-iron butterfly dampers is provided, so that either side of the whole of the chamber may be closed to the passage of gases. In Fig. 26, "Longitudinal Section," is shown the method of operating them, they being opened or closed by a motor.

The device for shaking the wires of the first group has proved to be unnecessary. The temperature of the gases being under 400° F., the dust will accumulate on them. This dust is removed periodically by admitting alternately at either side the hot reverberatory gases at the points already mentioned. This results in volatilizing and disintegrating the material on the wires so that it breaks up and the greater part falls off.

For the second group of wires, the shaking device described in MINERAL INDUSTRY, XVII, 251, and XVIII, 194, is still used. In Fig. 24, both in the longitudinal section and transverse sections, is shown, not only the shaker frames, but also the shaft, eccentric connecting-rod, and bell-levers, which shake the frames. Every 2 or 3 months the wires are shaken for half an hour in order to clear them from dust.

For the dust-chamber (as well as for other parts of the flue system) a structural steel framework is used. The inner columns, lower and upper, are of box section, those of the outside are of 12-in. I-beams, between which a curtain-wall 11 in. thick of special perforated brick is built. The main roof consists of longitudinal 18-in. I-beams on which are

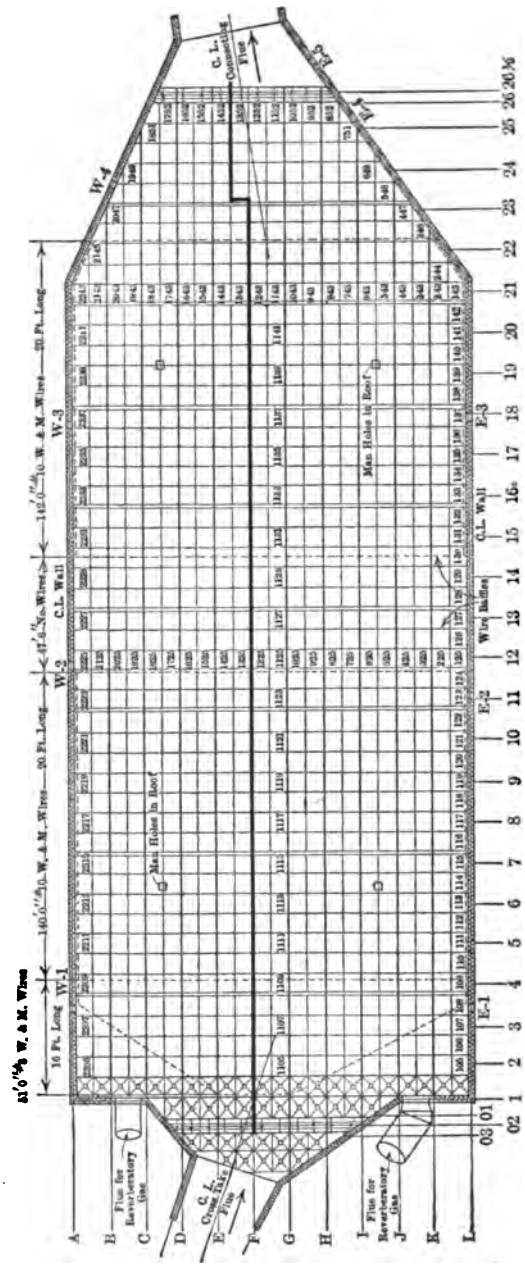


FIG. 27.—Hopper plan of dust chamber.

laid 8-in. steel I-beams as purlins, spaced at 3 ft. 4 in. centers, and between them are spring arches 5 in. thick of special perforated brick, the skew-back brick being molded to fit the I-beam. The skew-back was then filled with concrete and given two coats of a one-to-one concrete wash, to fill the cracks and to shed water.

To provide for the longitudinal expansion of the steel structure, the framework is built in units of three to seven panels, the middle panel of the unit being securely braced. The 18-in. roof-beams are rivetted to the tops of the columns, except the one midway between the braced panels, and there the beams are suspended from the columns by links, as

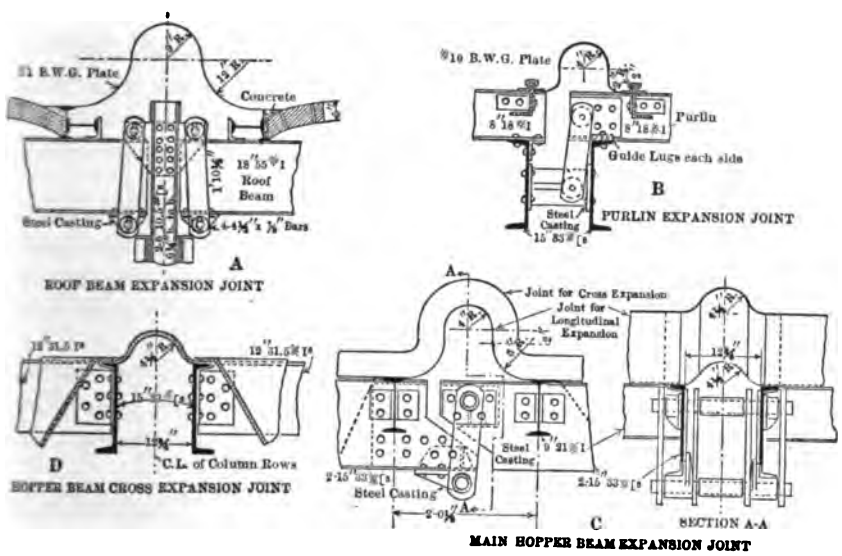


FIG. 28.—Details of expansion joints.

shown in Fig. 28 *A*. The roof between the purlins on each side of the expansion joint is made of No. 10 sheet-steel, bent as shown in the figure. There are seven of these joints extending across the full width of the flue.

To provide for the expansion of the 8-in. purlins, as shown in the transverse section, two joints are provided running the full length of the dust-chamber, thus dividing the roof into three sections, the middle panel of each of these sections being securely braced. The detailed drawing of this joint is shown in Fig. 28 *B*.

The bottom of the dust-chamber is composed of pyramidal steel hoppers, 1042 in all. To carry these hoppers longitudinal 15-in. channels are rivetted to the sides of the lower columns. Coped to these are 12-in. I-beams, and to them 8-in. I-beams, making them all flush on their upper surface and dividing them into rectangles to receive the hoppers.

The 12-in. transverse I-beams are built against the 15-in. longitudinal channels at points one-fourth the span between the columns, so that as they expand they can spring the channel. As in the roof, there are two systems of expansion joints, one longitudinal system at each row of columns, and a transverse set as shown in Fig. 26, "longitudinal section." A special transverse expansion joint is shown at the damper panels at either end of the dust-chamber.

Dust is transferred from the main dust-chamber to the furnaces by 80-cu. ft. hopper-bottom cars of an over-all length of one hopper. Thus only one setting of the train is needed when drawing off dust.

In the plan of Fig. 17 is shown the location of the "Connecting Flue," 48 ft. wide by 21 ft. high, and in cross-section at "Section *EE*." At every 110 ft. of its length on the east side, and at every 240 ft. on its west side, are openings 3 1/4 by 5 ft., provided with hinged cast-iron doors. Since little or no dust accumulates here, it was felt that these openings were sufficient.

It will be noted from the general plan, Fig. 17, that the "Connecting Flue" branches at the upper end, entering at the base of the main stack by two openings, each 36 ft. high by 15 ft. wide, thus retaining the cross-sectional area uniform. A cross-section of the flue, at its entry to the chimney, is shown at Section *FF*, Fig. 17.

Tooele Plant of the International Smelting and Refining Co.[1]—Officers of the Company, H. N. Thompson and L. T. Sicka, give us authoritative data of the plant. References to the copper-smelting department, not already given in the MINERAL INDUSTRY, are as follow:

The 4-mile aerial tramway of the Utah Consolidated Mining Co. has tram-buckets, each holding 1100 lb. of ore. This is dumped into inclined-bottom terminal bins of 800 tons capacity, and trammed thence to the receiving or custom bins by a 50-ton, electrically propelled, steel dump-bottom car. The receiving bins have a capacity of 4000 tons of ore, and in addition of 2500 tons for coal.

The charge to the MacDougall roasters averages only 22 per cent. sulphur, and hence needs the aid of 1 to 2 per cent. of coal to produce a satisfactory calcine. Several of the roasters have pipe hoppers leading from the charge floor to the fifth hearth of the furnace. By these hoppers enough siliceous ore is fed to the charge to give a slag of 41 per cent. SiO_2 at the reverberatory furnaces. This ore becomes mixed with the hot calcine coming down through the furnace as its crosses the fifth and sixth hearths, and before it drops into the discharge hoppers.

The converter-lining department, because of the adoption of basic converting, has been abandoned.

[1] *Trans. A. I. M. E.*, XLVI, 1209; MINERAL INDUSTRY, XIX, 199; XX, 233.

Ashes from the reverberatory furnaces are discharged into 7-ton, automatic, side-dumping cars. Matte is conveyed to the converter ladles by clay-lined launders sloping 0.875 in. per foot.

The charge to the reverberatories averages less than 2.5 per cent. Cu and produces a matte of 20 per cent. Cu for direct converting. No particular difficulty is experienced in converting, and 2 tons of ore of 70 per cent. SiO_2 are smelted for each ton of copper produced. At times it is desirable to treat the leady copper matte cold. This can be successfully accomplished by melting directly in the converters with the addition of 3 per cent. of coke and 1 per cent. of coal.

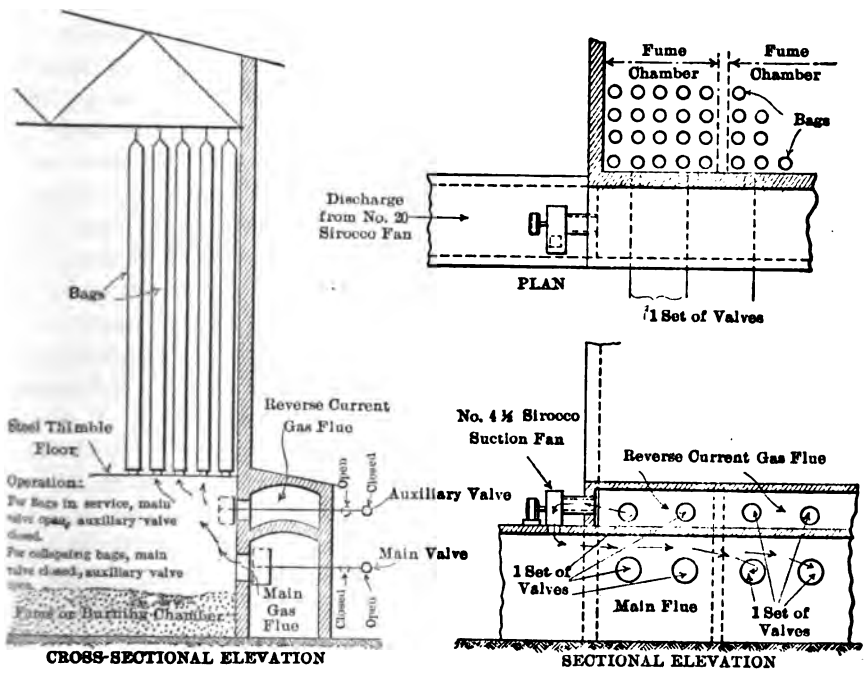


FIG. 29.—Reverse current bag-shaking system.

The converters are lined with magnesite brick. For them, air pressure at 10 to 11 lb. per square inch has been found most satisfactory, while siliceous ore is charged into them by crane in 2-ton capacity "boats" or scoops. Converter slag is poured from the converter ladles into shallow beds, broken up sufficiently for loading into cars with the aid of the travelling crane, and shipped to the crushing plant, to be prepared for lead blast-furnace use. It is no longer returned in molten form to the reverberatory furnaces. The converter copper is taken in ladles by the 30-ton travelling crane to be cast in steel molds.

The fumes from the five converters are now passed through a converter bag-house, similar to the bag-house used in lead-smelting practice. These fumes are gathered in a steel flue running parallel to the converter house, then by its continuation at right angles to the intake of a No. 2 Socorro fan with a rating of 180,000 cu. ft. per minute. This discharges directly into the main gas flue, which extends the full length of the bag-house. In case of the occurrence of a sudden excessive temperature, which might burn the bags, the gases may be by-passed and discharged directly to the bag-house stack.

The brick bag-house building, Fig. 29, is divided beneath the steel thimble floor by transverse walls into eight fume-chambers or "cellars." Above the thimble floor in the bag-house is a single large chamber containing 960 woolen bags, 18 in. in diameter by 30 ft. high. Normally, the flow of gases is into the fume-chambers, but it can be cut off from any chamber by a main disk-valve, operated from outside the flue. By shaking them the bags are from time to time relieved of the dust, which accumulates within them. Above the main gas flue is the reverse-current gas flue arranged with openings (normally closed) with disk-valves, which lead into the fume-chamber. One end of this reverse-current flue is connected with the intake of a No. 4 1/2 Socorro suction fan, which discharges into the main gas flue. Upon opening the upper set of valves of any chamber and closing the lower set the 120 bags of that chamber collapse, thus loosening the flue dust within them. This operation can be repeated as desired till the bags are cleared.

Means are also provided for shaking the bags by hand if so desired. This is accomplished by means of a small chain fastened to the upper bag connection and extending through the side walls of the building. A handle is provided at each end. A steel spring located centrally on each chain permits of a vibratory shaking as the handles are pulled.

The gases, filtering through the bags, enter the single large chamber and are discharged thence by a brick downtake into the brick stack already referred to, which is 15 ft. diameter by 150 ft. high.

The converters treat not only the copper matte produced by the reverberatory furnaces, but also the leady copper matte of 10 to 13 per cent. Cu which comes from the silver-lead blast-furnaces, and consequently contains the volatilized metals, copper, lead, zinc, etc.

The Steptoe Valley Smeltery.[1]—Pope Yeatman in his report discusses changes in smelting. Many improvements have been made in the 18-ft. MacDougall roasters by which their capacity, formerly 60 tons, has been increased to 90 tons per day. The rabble arms are cooled by air, thus increasing capacity.

[1] Annual Report, Nevada Cons. Copper Co., 1912; MINERAL INDUSTRY, XVI, 342; XVII, 204; XX, 189.

The reverberatory furnaces, 19 by 112 ft., are now oil-fired. The average amount smelted per furnace day has been increased from 262 in the year 1911 to 371 tons for the year 1912, and in the latter part of the year, even better work than this average has been done. This has been brought about by changes in the method of firing, improvement in the design of the furnace, and by better operation.

In the converting department are now two Pierce-Smith basic-lined converters, which have been improved in operation.

Cananea Consolidated Copper Co.[1]—In 1912 the company has added the following: (1) Two upright converters of the Great Falls type, 12 ft. 3 in. in diameter, of shell and having 24 tuyères. (2) In 1913 the four barrel type converters have been replaced by four upright converters having 30 tuyères each. All the six converters are to be basic-lined. (3) Two straight-line casting machines.

There are ten 18-ft. six-hearth MacDougall roasters, six of them being now in use. Cananea concentrate, containing 30 to 35 per cent. sulphur, is roasted in these at the rate of 40 tons per day per furnace, the calcine carrying 6–7 per cent. of sulphur.

The blast-furnaces, with a 7-ft. smelting column, carry a blast of 26 oz. per square inch. Each 48 by 210-in. furnace smelts 300 tons per day, using 10 per cent. of fuel and producing 10 per cent. of flue dust. The charge consists of lump ore, custom ore, converter slag and 45 to 50 tons daily of raw concentrate per furnace. Seventy per cent. of the sulphur of the charge is volatilized, and a matte of 35 per cent. Cu is produced.

The calcine and 75 tons daily of raw Miami concentrate is smelted in the two 19 by 100-ft. reverberatories. The oil is heated by a steam-coil in the oil tank, and is injected by air at 13 lb. per square inch pressure, the former burners, which used both air and steam for injection, having been discarded. To ensure its more even distribution, air for combustion is also admitted through a checker-work above the burners. For fettling, some 75 tons daily of wet Miami concentrate, containing 21 per cent. S and 35 per cent. Cu is dropped through the fettling holes (MINERAL INDUSTRY, XVIII, 188, Fig. 2). This is better than silicious ore, which, as formerly used, produced "floaters." The two reverberatories have eight waste-heat boilers in all, three of 250 h.p., two of 225 h.p., and three of 200 h.p. These yield 1000 h.p., the remaining steam needed being supplied by oil-fired boilers.

The converters are to handle 400 to 500 tons of matte per day, producing 150 tons of blister. In addition, some 50 tons of Miami concentrate is blown in at the tuyères by means of a special blow-pipe. The

[1] *Eng. Min. Jour.*, XCV, 335; *Min. Sci. Pr.*, CVII, 526; MINERAL INDUSTRY, XVII, 255; XVIII, 185; XX, 216.

concentrate is dried, and during the blow, is introduced through one tuyère at a time in order to prevent local chilling. Its silica content serves to replace as much silica which would otherwise have to be charged through the converter mouth.

The El Paso Smeltery.[1]—This plant, originally a lead smeltery has added to its equipment, so that it could treat Chino ore From Santa Rita, N. M. These additions consist of:

(1) Five 22 1/2-ft. Wedge Roasters (three in operation, two building) having four hearths. They are designed to treat 100 tons each, but three of them are actually putting through 130 to 150 tons per day. The Chino concentrate contains from 12 to 22 per cent. sulphur, and this was more than had been foreseen, hence the furnaces are now overloaded, and do not completely dry the concentrate on the roof, the roast is therefore somewhat sticky as it enters the third hearth. To pass it through the central drop-hole the distributor plate had to be removed. This makes the roasted ore pile up at this point and from time to time lumps get between the central cylinder and the hearth-ring to the injury of the ring. To aid in furnishing heat an additional burner has been applied at the second hearth.

(2) Two blast-furnaces, 40 in. by 12 ft. long, smelt lump custom ore, giving a matte of 45 per cent. Cu.

(3) Two oil-fired, 19 by 104 ft., reverberatory furnaces smelt the calcine from the Wedge furnaces, yielding a 40 per cent. copper matte with a matte-fall of 30 per cent., each furnace handling 300 tons daily, though the capacity is in excess of this, but is limited by what the roasters can supply.

The Hayden Smeltery.[2]—This new plant of the American Smelting & Refining Co. was completed in 1912. It treats the product of the Ray Consolidated Copper Co. About 600 tons are treated daily, the reverberatory charge consisting of 20 per cent. crude ore and 80 per cent. of roasted concentrate. Besides the eight roasters, there are two reverberatory furnaces each 19 ft. wide by 112 ft. long, which produce a matter of 25 to 40 per cent. Cu. This is treated in two Pierce-Smith basic-lined converters, 25 ft. long by 10 ft. diameter, or in one 12-ft. upright converter.

The wet concentrate from the mill of the Ray Consolidated, brought in railroad cars, is allowed to drain, sampled, dropped, in bins, and as wanted, withdrawn on conveying belts to go to the MacDougall roasters. There are eight of these, five 24 ft. diameter with five hearths, three of 19 ft. diameter having six hearths. The concentrate contains 24 per cent. sulphur, and to maintain the roasting temperature, needs

[1] *Min. Sci. Pr.*, CVII, 522.
[2] *Min. Sci. Pr.*, CVII, 521; *Eng. Min. Jour.*, XCV, 335.

the aid of some oil, burned from time to time in the fire-boxes. The furnaces handle 90 tons daily, the top of one five-hearth roaster being used for drying.

The reverberatories each smelt 350 tons daily with a consumption of 0.8 to 0.9 bbl. of oil per ton of charge. Slime concentrate is used for fettling. Waste-heat Stirling boilers furnish the steam needed for power purposes.

The blister copper from the converters is accumulated in an oil-fired receiving vessel and thence molded into anodes.

The Kedabeg Smeltery.—In addition to the illustrated description in MINERAL INDUSTRY, XIV, 181, we find additional details in *Glückauf*, May 10, 1912.

Arizona Copper Co. Smeltery.[1]—This new plant at Clifton, Arizona, erected at a cost of $2,500,000, has just been put in operation. The equipment included: (1) Eight Herreshoff roasting furnaces, 21 ft. 8 in. diameter of shell, (2) three reverberatory furnaces each 100 by 22 ft., or 3 ft. wider than the usual 100-ft. type. In consequence it is estimated that the furnace will have a 20 per cent. increased output. (3) Three 12-ft. vertical converters of the Great Falls type, having, with the grade of matte produced, an output of 50 tons daily per converter. Some 10 per cent. of the ore is crude, the remainder concentrate.

Detroit Smeltery.[2]—This is a blast-furnace plant of the Detroit Copper Mining Co. situated at Morenci, Arizona. There is one blast-furnace, 42 in. by 22 ft., driven slowly to put through 350 tons per day. The furnace charge is mostly concentrate, to which is added some lump ore. The concentrate contains Cu 15 to 17 per cent.; SiO_2 15 per cent. About 50 tons of limestone are used per day. The slag contains Al_2O_3, 7.2 per cent., and MgO 2.0 per cent. Some 60 to 70 tons of matte, containing 42 percent Cu, are produced daily. It is intended to substitute for the present furnace one 33 ft. long, in order to farther decrease flue-dust loss.

Converting is done in acid-lined shells, but these may be replaced by an upright basic-lined converter. For power supply the Crossley gas engine is employed, supplied with producer gas made in a Loomis gas generator.

Smeltery of the Shannon Copper Co.[3]—This is a blast-furnace works, situated at Clifton, Arizona. There are two blast-furnaces, one 42 in. by 15 ft. and one 44 in. by 30 ft. long, the latter handling about 700 tons daily. The furnaces have cast-steel crucibles, and these have given trouble by cracking. About 500 tons of the ore supply per day contains

[1] *Eng. Min. Jour.*, XCV., 335; *Min. Sci. Pr.*, CVII, 523; MINERAL INDUSTRY, XII, 93.
[2] *Min. Sci. Pr.*, CVII, 524.
[3] *Min. Sci. Pr.*, CVII, 524.

no sulphides and is smelted directly, the remainder, 300 tons per day, is concentrated 10 to 1. The fine concentrate is mixed with flue dust, then charged to the blast-furnace. The ore contains but little sulphur and in order to ensure a sufficient matte-fall, pyrite from Gleason, Arizona has to be added to the charge.

United States Metals Refining Co. Smeltery.—This works is located at Chrome, N. J. To the excellent description given by Lawrence Addicks in MINERAL INDUSTRY, XV, 301, we add details from R. H. Vail's article.[1]

The smelting charge consists of (1) oxidized ores from South America and Cuba; (2) pyrite ores from Spain and Canada; (3) pyrites cinder; (4) Cobalt silver ores, not exceeding 300 oz. silver per ton; (5) custom matte; (6) refining products, consisting mainly of slag and cobbing from

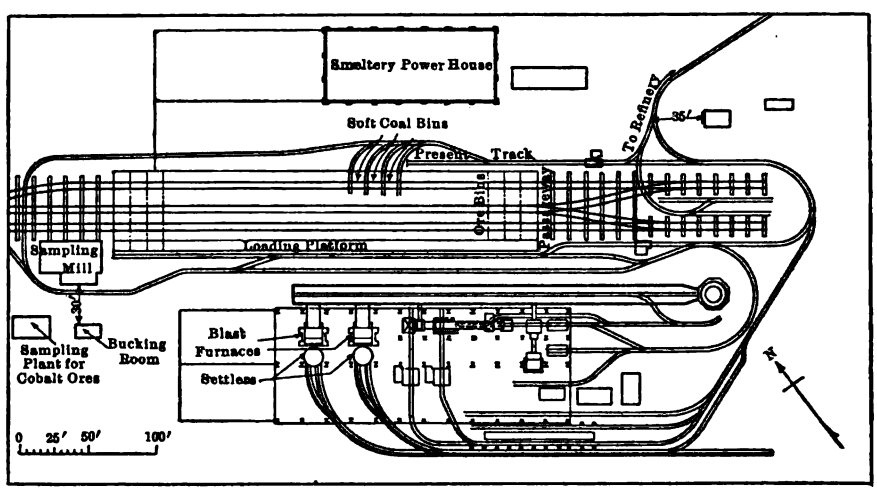


FIG. 30.—Layout of the smelter at Chrome, N. J.

the furnaces; (7) sweepings or clean-up materials; (8) nodulized flue dust.

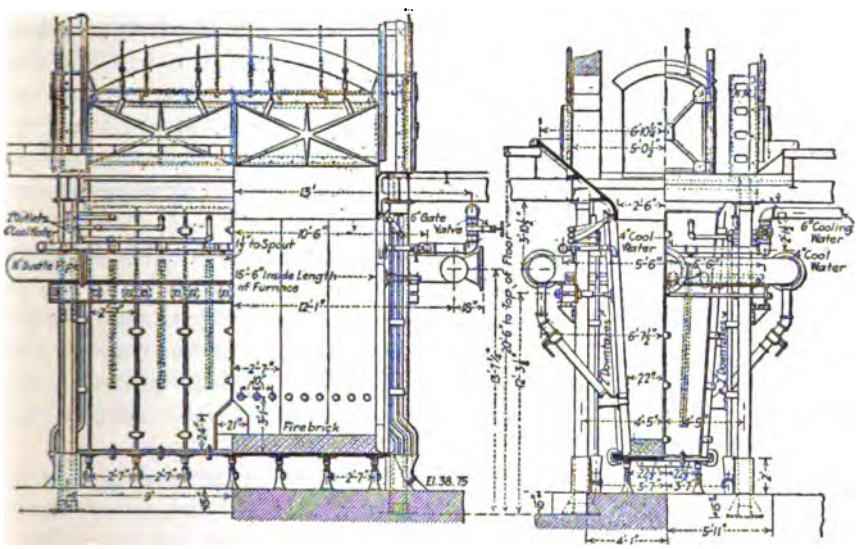
In December, 1912, one blast-furnace smelted 9587 dry tons, containing on an average: Cu, 16.3 per cent.; Fe 26.6; Insol. 24.1; CaO, 0.5; S, 17.5; together with Ag, 4.24 oz. and Au 0.123 oz. per ton.

In unloading foreign ores from vessels, the ore is dumped from buckets into cars, or if sacked, is hoisted, ten sacks together, to a platform laid loosely on a railroad car. The platform has a lengthwise slot 12 in. wide. The sacks, having been cut open, are rapidly emptied through the slot into the car.

Rich ore, such as that from Cobalt, after having been mechanically cut to one-twenty-fifth of its volume, is taken to a sampling plant separate from the main one.

[1] *Eng. Min. Jour.*, XCV, 1031; MINERAL INDUSTRY, XV, 301; XVII, 326.

Fig. 30 is a plan of the smeltery, represented on a small scale in MINERAL INDUSTRY, XV, 303. Railroad tracks, from the docks and the Central R. R. of New Jersey, branch into three parallel tracks over the ore bins. The bins have flat bottoms and side openings for the removal of the ore. Because of the cheap labor and the small tonnage handled, it was not thought worth while to change the bins for direct charging into cars; the train tracks therefore enter the bins and small end-dump cars are filled by shoveling into them just the required amount. The cars are then run outside the bins to the end of the track which terminates with bent-up ends. Here, at the edge of the "loading platform," they are dumped into charge-cars, standing on a track parallel to



FIGS. 31 AND 32.—Blast furnaces at Chrome, N. J.

the edge of the platform. The furnace charge is thus made up by volume, but quantities are checked by occasional weighing. The shovellers soon become expert in estimating the correct amount.

The charge-train consists of two side-dump cars of 8500 lb. each, one of the cars being motor-driven. Two charge-train crews handle all material to the blast-furnace, while a third crew on the day shift only hauls converter flux and flue dust. The charge trains are lifted to the feed-floor by two Reedy 10-ton electric lifts.

There are now two 44 by 186-in. blast-furnaces (Figs. 31 and 32). Each furnace has six jackets per side and two at each end, or 16 in all, extending in single tier to the receiving plates. The tuyère-thimbles are of extra heavy wrought pipe welded by an oxyacetylene flame to the

inner and outer plates. This method of welding is also used for patching the jackets, though not so successful in repairing the cast-steel ladles. Below the end jackets comes the breast jacket, made of wire-bar copper poured around extra heavy 1 1/4-in. pipe for water circulation. The other end of the furnace beneath the jackets having no breast-jacket, is bricked up. The steel water-jacketed spout has a cast-iron lip cooled by a water-pipe. The blast is trapped 8 1/2 in. The bottom or base-plate is lined with 12 in. chrome or magnesite brick. The settlers are 14 ft. diameter and are lined with chrome brick. The furnace down-takes discharge into an elevated brick-and-steel flue 288 ft. long, 12 ft. wide and having a cross-section of 170 sq. ft. The flue has a hopper bottom, so that the flue dust can be readily drawn into cars running beneath. Terminating the flue is a stack 200 ft. high by 12 ft. diameter. Air is supplied by a No. 9 Root Blower, direct connected to an 11-in. and 24-in. by 36-in. tandem-compound Hamilton engine operated at 150 lb. steam pressure and with a vacuum of 26 in. The blower, running at 100 to 140 r.p.m., supplies air to the blast-furnaces through a 32-in. main at 36 oz. pressure per square inch. There is also a 6000-cu. ft. per minute blower connected to this main.

The furnace charge, usually 8500 lb., is dumped into the furnace separately from the coke, which amounts to 11 to 12 per cent. of the charge. With one furnace in operation about 350 tons per day are smelted, equal to 6.16 tons per square foot of hearth area. The second furnace is held ready for instant blowing-in if necessary. The slag is granulated, using sea water supplied by centrifugal pumps. The granulated slag is sold for ballast, or if high enough in iron, for its iron contents.

Iron-bearing material is so abundant that it has proved to be more economical to use a ferro-silicate slag, and to avoid the use of barren limestone flux. The normal slag, used for ballast, has the composition; FeO, 50.67 per cent.; SiO_2, 32.05; CaO, 1.37; S, 0.77; Cu, 0.76; MgO, 1.06; $BaSO_4$, 3.1; PbO, 22; As, 0.094; Ni, 0.07; Al_2O_3, 4.1; Zn, 2.35; P_2O_5, 0.063; Mn, trace; with Ag 0.16 oz. and Au 0.0025 oz. per ton. When a slag is to be sold, it must be made to contain not less than 43 per cent. iron. A typical slag thus made contained FeO, 59.78 per cent. (Fe 46.39); SiO_2, 25.24; CaO, 0.7; S, 0.7; Cu, 0.79. The principal difficulty in this connection is to secure a slag sufficiently low in sulphur to suit the purchaser. The large amount of copper on the charge, and the consequent high grade of matte, results in a high copper percentage in the slag, this difficulty being further aggravated by the high specific gravity of the iron slag. It is believed, however, that it is better to submit to this loss than to purchase and smelt barren limestone. The matte-fall averages 14 per cent., and the grade of the matte

varies from 40 to 70 per cent. copper, usually between 50 to 60 per cent. The matte carries up to 3 per cent. nickel, which is later recovered in the electrolytic refinery.

The flue dust amounts to about 10 per cent. of the charge. In a monthly sample it averaged: Cu, 10.75 per cent; Fe, 32.02; Insol, 20.83; CaO, 0.82; S, 8.24; As, 0.88, with Ag, 15.2 oz. and Au, 0.17 oz. per ton. (Comparing this with the analysis of the charge we note that half the sulphur has been dissipated in the smelting operation while the precious metals, especially the silver, have increased in this by-product. L. S.A.). The flue dust is nodulized, using a cement kiln, a revolving cylinder 6 ft. in diameter, by 60 ft. long, lined with fire-brick and fired with oil. The dust is fed to the kiln by a screw-conveyor protected by a water-jacket, and about 50 tons of flue dust are nodulized in 24 hours. The product is satisfactory. The kiln consumes 500 gal. of oil per day and needs one attendant per shift.

The matte is now converted in basic-lined shells under license from the Pierce-Smith Converter Co., the original shells, formerly acid-lined, being used. Air is now supplied at 10 lb. pressure. A little trouble is experienced, due to accretions at the mouth of the converter when 70 per cent. copper matte is being treated, but at present the matte rarely exceeds 55 per cent. The converters operate smoothly. For converter flux, oxidized ore, carrying 60 per cent. SiO_2 is used. This is dried in a steel cylindrical dryer 30 in. in diameter by 20 ft. long. The dryer is unlined, and has within it six longitudinal shelves. Oil is used for heating and 1000 gal. are used per month to dry 650 tons of ore.

The converter hood, of the design of C. L. Brower, consists of two steel castings bolted together. It is of smaller section than is usually considered necessary, and its circular mouth appears to be just in the right position to take the fumes, so that the converter room is unusually free from smoke. When the hood becomes clogged with accretions, it is removed by crane and replaced by another; the first hood may then be cleaned at leisure.

Two 40-ton cranes serve the converter floor, one being occupied much of the time in pouring copper. When a charge is finished it is received into a special tilting-ladle, and from this poured into a series of copper molds mounted on eight narrow-gage trucks, four molds to a truck. In this way the converter is not delayed by a tedious pouring, but is speedily free to proceed with fresh charge. The bars from the molds are unloaded upon a platform, and on day shift trimmed and loaded on refinery cars, using for this purpose a travelling crane carrying a 1/2-ton hoist. The converter slag is poured into the blast-furnace settlers.

In a recent month 3,300,000 lb. of copper were converted in this plant.

A basic lining will, on the average, last for the production of 1,500,000 lb. of copper before needing repair at the tuyéres, and in one case for 2,000,000 lb. None of the basic-linings in 18 months service have been entirely replaced, and the principal repair has been the patching about the tuyères. In the operation of lining, magnesite bricks are laid with a mortar of sodium silicate (water-glass) and pea-grain size magnesite on a bed 1 in. thick, this to allow for expansion. At the tuyères, in place of brick, a belt of material, composed of 80 per cent. fine magnesite and 20 per cent. water-glass, is tamped in to the height of 8 to 10 in. by 14 in. thick. In 30 minutes this has set fairly well, and in a few hours is as hard as the brick portion. For the tuyère connection a 1 1/4-in. double extra-heavy wrought-iron pipe is used. The work is performed expeditiously. Converter air is supplied through a 20-in. main by a Nordberg cross-compound blowing engine with steam cylinders respectively 13 and 28 in. in diameter and two 30 in. single-stage air cylinders, all with a stroke of 42 in. This unit operates at 130 r.p.m. with a steam pressure of 130 lb. per square inch with a vacuum of 26 in. of mercury, and supplies air at 12 lb. pressure per square inch at the blower.

The United Verde Smeltery.[1]—The works of the United Verde Copper Co., is situated at Clarkdale, Arizona, 6 miles from Jerome, by rail. The equipment comprises six Wedge roasting furnaces, three reverberatory furnaces, four blast-furnaces, 48 by 28 1/3 ft., and four 12-ft. upright converters.

Fig. 33 is a general plan of the works, and shows a grouping into two parts. In the first group are the bins and trackage handling the ores, in the second the smelting equipment, compactly arranged around the main stack. On the east side are the subsidiary buildings and the power house.

The cars, containing fuel and ores, after weighing over a 150-ton track-scale, enter the yard at the southwest corner and the ores are unloaded, either at the receiving bins or to the storage yard. The receiving bins, 41 by 270 ft., have a capacity of 12,800 tons, and two unloading tracks go over them 42 ft. above the ground. At the same level is a conveying belt and a movable tripper by which reclaimed ore can be delivered to any desired bin. The bins have sloping bottoms, so that ore can be drawn either into weighing hoppers and thence into furnace charge-cars, or, for crushing and sampling, to 30-in. belt conveyors that travel beneath and parallel with the bins. From this belt the ore is dropped on a conveying belt at right angles, delivering to the crushing plant.

Immediately east of the receiving bins, similarly arranged except that there are no railroad tracks, are storage bins also 41 by 270 ft., but

[1] *Min. Sci. Pr.*, CVI, 305; *Eng. Min. Jour.*, XCVI, 287.

of 14,200 tons capacity. West of the receiving bins are the coke and ore storage yards. Over these yards run elevated tracks on steel trestles. The coke storage is 73 by 270 ft., the ore storage 60 by 270 ft. Ore, delivered by the cross-conveyor to the crushing plant, is there crushed through a 30 by 18-in. Blake ore-breaker, then taken for sampling by a belt conveyor of 100 tons hourly capacity to the 42 by 40-ft. crushing and sampling mill.

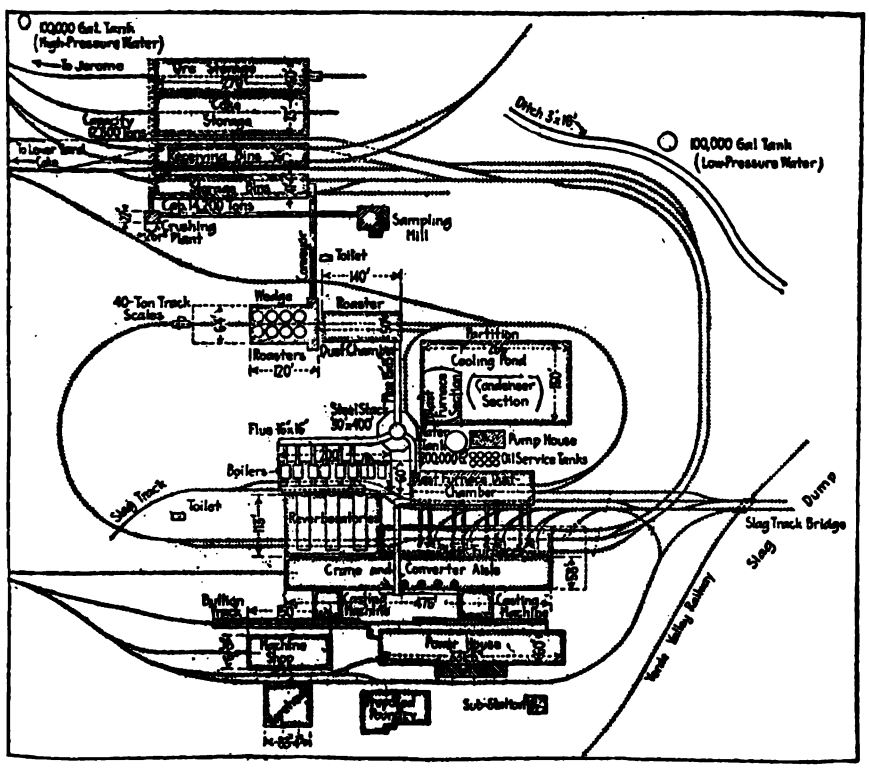


FIG. 33.—Layout of the United Verde Works, Clarkdale, Ariz.

The crushing section of this mill has two revolving screens, 4 ft. in diameter by 14 ft. long. One of these is a double screen, having 1 in. and 1/2 in. perforations respectively; the other has a single 1/2-in. screen and an outer blank jacket. For crushing there are a 20 by 10-in. Blake ore-breaker and a pair of 54 by 24-in. rolls, set to crush 3/8 in. The sampling section of the mill has four Snyder sampling machines arranged to cut one-tenth, one-fifth, one-fifth and one-tenth respectively, or to one twenty-five hundredth in all. Between the first and second samplers the sample is crushed by a 20 by 10-in. Blake crusher; between the second and third by

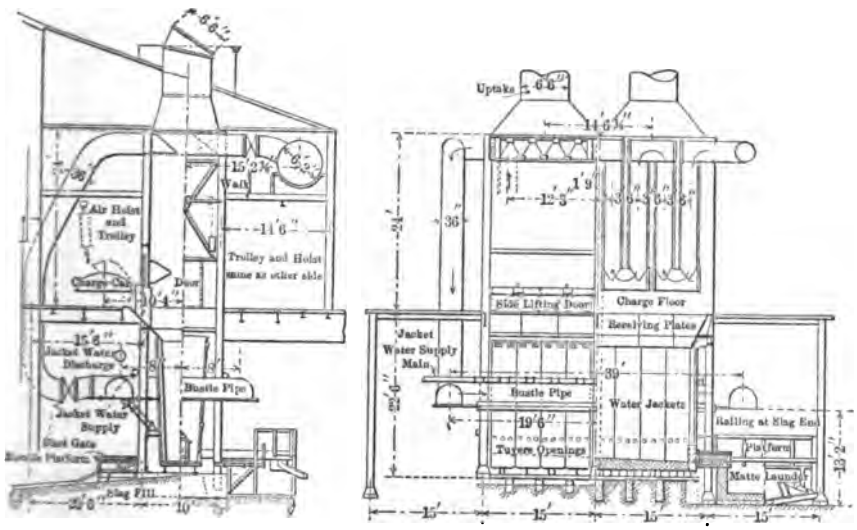
36 by 12-in. rolls; between the third and fourth by 24 by 12-in. rolls. The rejected ore is sent by suitably arranged belt-conveyors to the storage bins.

The roaster building, 64 by 120 ft., contains six air-cooled wedge furnaces of 21 ft. 6 in. diameter of the shell. Two 25,000-cu. ft. per minute fan blowers supply them with air at a pressure of 2 oz. per square inch. Crushed ore from the storage-bins is brought to the roaster building by belt-conveyor. The gases from the roasters go to a 50 by 140-ft. dust-chamber, which has a double hopper bottom with a 45-degree slope. The hoppers have a vertical height of 14 ft., the dust-chamber is 21 ft. high. The dust-chamber is of steel construction with brick curtain walls, and is roofed with sheet copper, No. 24 gage. Near each end, in order to evenly distribute the entering and leaving gas current are baffle curtains. These consist of plates 6 in. wide, set 6 3/4 in. center to center, thus leaving a 3/4 opening between them, and extending from the roof to the bottom of the chamber. Each bar has two angle pieces riveted to it at the top and resting on 6-in. channels. It is easy to slide and space the plates and regulate the gas-flow. A flue, 13 by 13 ft., connects the dust-chamber to the main stack. The calcine is withdrawn from the roaster into a special car having double hopper-bottoms. The car, 16 ft. long, has two trucks. It is hauled by a 10-ton locomotive over a 40-ton track scale to the reverberatory furnaces, arriving there on tracks 20 ft. above the ground. There are three parallel delivery tracks, two for ore and one for coal.

The main furnace building is 143 ft. wide by 475 ft. long with 143 ft. at the south end devoted to the reverberatory building. The reverberatories are 19 by 100 ft., built with silica-brick, and fired with oil. On either side of the furnace is shown in Fig. 30 the trolley beam for fettling (see MINERAL INDUSTRY, XVIII, 188, Fig. 2). The gases from the reverberatories go to the main header-flue in the 60 by 200-ft. boiler-house. From this header-flue, branches lead to six waste-heat Stirling boilers of 713 h.p. each. Thus it is possible to cut out any boiler for repairs without having to by-pass the gases of any furnace to the stack. There are also three reserve oil-fired Parker water-tube boilers. The waste-heat boilers are expected to realize 70 per cent. of their rated capacity, and to recover in steam production 30 to 35 per cent. of the calorific power of the oil. The boilers will be equipped with superheaters, which will give the steam 100° F. of superheat. The gases from the waste-heat boilers finally pass to the stack by a flue 16 by 16 ft. by 207 ft. long. The oil for the Parker boilers and for the reverberatories is taken from eight oil-service tanks near the pump house. Additional oil storage is provided at a 10,000 gal. tank near the trestle of the receiving bins, so situated that the oil can

be run into it by gravity, and likewise taken out by gravity for the locomotives and for other uses about the plant.

The blast-furnace building, occupying the north portion of the main furnace building, has four furnaces arranged with their longitudinal axes in line. At the north end, and between the furnaces, are set transversely the oval settlers 26 ft. by 12 ft. 9 in. lined with chrome brick. Figs. 34 and 35 show two elevations, giving details of construction of the blast-furnaces. The charging tracks are arranged one on each side of the furnaces for ore, and one outside of the building for coke. The furnace base-plate, 4 ft. above the ground, rests on I-beams and these on a solid foundation. There is a single tier of jackets, eight to each side and two at each



FIGS. 34 AND 35.—Blast furnaces at Clarkdale, Ariz.

end, 16 ft. high. These meet the receiving plates which takes the ore from the charge-cars. There are 24 tuyères per side, spaced at 13 1/4-in. centers. Each furnace has a closed top of structural steel with a steel air-jacket for preheating the blast. Air, by a branch pipe from the 6 ft. 2 in. main, circulates through the jacket, then goes downward to the flat-bottom bustle-pipe below. From the underside of the bustle-pipe the tuyères take off, entering the jackets 4 ft. above the base-plate. On one side of the furnace the floor slopes away from the top of the foundation to the converter house, and on this stands a movable platform for convenience in punching the tuyères; on the other side a platform at the settler gives convenient access to the slag-spout. The slag from the blast-furnaces (and from the reverberatories) will be taken away in electrically

tilted slag-cars with bowls of 225 cu. ft. or 25 tons capacity drawn by 18-ton electric locomotives. The slag tracks will cross the Verde Valley Railway at an elevation of 26 ft. on a reinforced concrete viaduct. The side walls of the viaduct serve to protect the railway below from the splashing of slag. Coke is brought in railroad cars upon the outside track; it will be unloaded from the cars directly into charge-barrows.

From the top of the furnace two goose-neck off-takes 6 ft. 6 in. diameter go to the blast-furnace dust-chamber. This chamber is 60 ft. by 220 ft. long and of similar construction to the roaster dust-chamber but is 29 ft. above the hopper line; the hoppers have a vertical height of 19 ft. The baffle plates are arranged as in the other chamber. There is a longitudinal curtain extending nearly parallel on one long side of the chamber, thus making a passage for leading the blast-furnace gases to the north end of the dust-chamber. A 12-ft. by 14-ft. steel flue leads from the chamber to the main stack.

There will be five 12-ft. upright basic-lined converters, each electrically operated by a 50-h.p. motor. Four of these converters are to be at once installed. They will be served by two 40-ton Morgan traveling cranes of 55 ft. span, operating in a converter building 475 ft. long by 58 ft. wide. Converter slag may be poured from a ladle into slag launders leading to the reverberatory furnaces, or if desired, into the blast-furnace forehearths. Matte, either from the reverberatories or from the forehearths, is conducted by launders to the side of the converter building, there to be received in ladles for converting. The converter gases are carried by a balloon flue to the nearest corner of the blast-furnace dust-chamber.

In casting sheds, adjoining the converter aisle, are two straight-line casting-machines of special design. Copper will be transferred from the converter by ladle to the casting-machine tilting stands. The ingots, as they are cast, will be set next to a track, sunken to bring the car-floor level with the casting-shed floor.

The main smeltery-stack is 30 ft. in diameter by 400 ft. high, of steel, lined with a 4 1/2-in. course of selected red brick. It will rest on a concrete base, 70 ft. in diameter by 10 ft. deep, reinforced with 20 tons of second-hand rails.

A cooling pond, 150 by 266 ft., of 1,000,000 gal. capacity receives the hot condensed water from the power-house and the jacket water from the blast-furnaces. The pond is built of reinforced concrete lined with asphalt. At 73 ft. from the south side of the pond is a partition which keeps the jacket water separate from the condenser water. The entering water is sprayed through nozzles, eight sets of five nozzles each for the jacket-water, and forty-four sets of five nozzles for the condenser water. In the adjacent pump house, besides the boiler-feed pumps, there are two

centrifugal pumps for pumping jacket-water to the spray-nozzles, and two pumps for returning the cooled water to the 200,000 gal. water tank.

Copper and its Alloys

Volatilization, Melting Point and Boiling Point of Copper.[1]—G. W. C. Kaye and D. Ewen give for copper the following data: The volatilization of copper is first to be detected at 400° C., its melting point is 1084° C., its boiling point *in vacuo* is 1600° C., and its boiling point at ordinary atmospheric pressure is 2310° C.

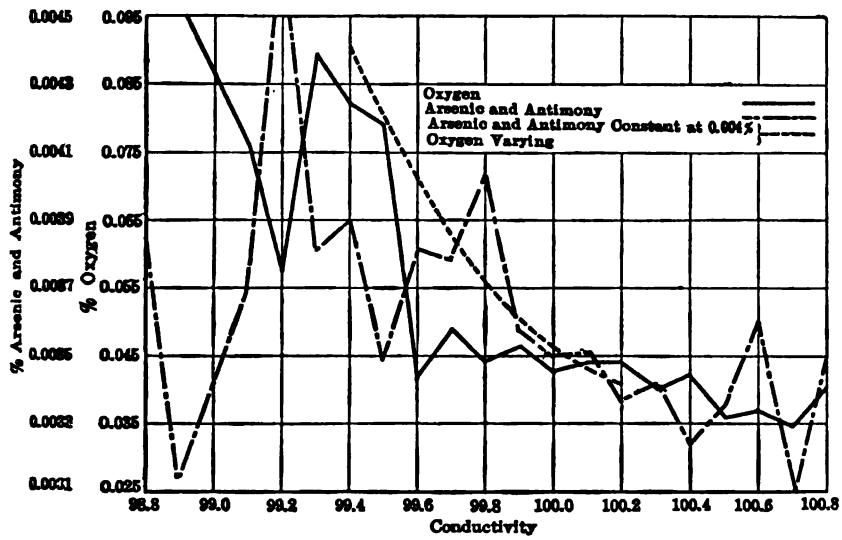


Fig. 36.—Conductivity curve of refined copper.

Conductivity of Refined Copper.[2]—Earl S. Bardwell shows how it is possible to rapidly determine the percentage of oxygen in refined copper by micrographic methods. He polishes the sample, etches it with hydrogen, and takes of the same a magnified photomicrograph on paper. The eutectic network shows the cupric oxide standing out black on the nearly white background of pure copper. The copper areas are cut out, and the eutectic network is weighed against the cut-out portions to ascertain the percentage of cupric oxide. In this way the oxygen-content has been plotted in graphic curves as shown in Fig. 36.

From the curve we see, that while a decrease in oxygen content coincides with an increase in conductivity, the curve is irregular, and depends on the combined effect of the impurities, and not on the oxygen-

[1] *Royal Soc. Proc.*, A LXXXIX, 58.
[2] *Trans. A. I. M. E.*, XLVI, 1429.

content alone. (Arsenic and antimony are lumped, but it must not be forgotten that the former of the two metals effects conductivity more than the latter. L. S. A.)

Melting Points of Some Copper Alloys.[1]—The carefully made determinations of the melting points of certain ternary and quarternary copper alloys are as follows:

TABLE XIII.

Alloy.	Composition Desired.				Composition by Analysis.				Number of Duplicate Determinations.	Melting Point (Liquidus).	
	Cu.	Zn.	Sn.	Pb.	Cu.	Zn.	Sn.	Pb.			
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*° C.*	*° F.*
Gun metal	88	2	10	.....	.....	.....	.....	.....	4	995	1,825
Leaded gun metal	85½	2	9½	3	85.4	1.9	9.7	3.0	6	980	1,795
Red brass	85	5	5	5	.....	.....	.....	.....	8[2]	970	1,780
Low-grade red brass	82	10	3	5	81.5	10.4	3.1	5.0	4	980	1,795
Leaded bronze	80	.....	10	10	.....	.....	.....	.....	3	945	1,735
Bronze with zinc	85	5	10	.....	84.6	5.0	10.4	.....	4	980	1,795
Half yellow, half red	75	20	2	3	75.0	20.0	2.0	3.0	3	920	1,690
Cast yellow brass	67	31	.....	2	66.9	30.8	.....	2.3	4	895	1,645
Naval brass	61½	37	1½	.....	61.7	36.9	1.4	.....	5	855	1,570
Manganese bronze	.....	.....	.....	.....	.....	.....	.....	.....	6	870	1,600

These are to be compared with the melting points of certain binary (copper-tin, copper-zinc and copper-lead) alloys as below:

TABLE XIV.
COPPER-TIN ALLOYS.

Parts by Weight.		Melting Point.[3]	
Copper.	*Tin.*	° C.	° F.
95	5	1,050	1,920
90	10	1,005	1,840
85	15	960	1,760
80	20	890	1,635

COPPER-ZINC ALLOYS.

Copper.	*Zinc.*	° C.	° F.[4]
95	5	1,070	1,960
90	10	1,055	1,930
85	15	1,025	1,880
80	20	1,000	1,830
75	25	980	1,795
70	30	940	1,725
65	35	915	1,660
60	40	890	1,635

[1] U. S. Bureau of Mines, *Technical Paper* 60.
[2] Two samples.
[3] *Jour. Phys. Chem.*, IX, 446.
[4] *Jour. Phys. Chem.*, VIII, 423.

COPPER-LEAD ALLOYS.

Copper.	*Lead.*	° C.	°F.[1]
95	5	1,065	1,950
90	10	1,050	1,920
85	15	1,035	1,895

ORGANIZATION

Smeltery Organization.[2]—Dr. Douglas describes the former organization of the Copper Queen Cons. Mining Co., including both mine and works. For many years the technical staff consisted of a superintendent, an assistant (who was also metallurgist), one chemist, and a mining engineer who with the aid of a rodman did the mine surveying.

To-day, with larger output, the use of electricity, of high-grade steam equipment, of increased chemical work and of the study of the ore deposits, the staff would include: At the mine; a mine superintendent, an assistant consulting geologist; a chief resident geologist and three assistants; three chemists, a chief consulting electrician, a chief operating electrician with ten assistants, a chief engineer and thirteen assistants. In the smelting department would be a superintendent, an assistant superintendent and two "under studies," a mechanical engineer and electrician with twelve assistants, five experts engaged in experimental work, and in the assay office a chief chemist and three assistants.

PROGRESS IN ELECTROLYTIC COPPER REFINING DURING 1913

BY LAWRENCE ADDICKS

The electrolytic refining of blister copper has become standardized to such an extent that there is but little in the way of progress to be noted in a single year. Most of the individual plants have now reached such a size that there is not much saving to be made from increase in capacity, and further expansion is likely to be at a slower rate. While the quantity of copper produced will doubtless steadily increase much of this new material will be non-argentiferous and will not therefore reach the refineries. The so-called Katanga copper from the Belgian Congo will doubtless be produced as a black copper nearly free from values which will be refined by fire process to a high-grade casting copper, unless some unexpected market for the cobalt which is associated with these ores causes a change in the metallurgical scheme. As the production from this source should be quite large, the interesting question of how much casting copper can

[1] Desch, *Metallography*, p. 85.
[2] *Trans. Inst. Min. Met. Bull.*, 110, 19.

be marketed will be raised and may bring about a more rational classification of copper for special uses than at present obtains.

A second large source of new production is in Chile at the Chuquicamata development of the Chile Exploration Company. This ore again carries negligible quantities of gold and silver and the copper will be recovered by leaching and electrolytic precipitation on the ground, the resulting cathodes being shipped to some point not yet determined upon for melting. A third promising field is in the leaching operations now being conducted at various points in the western United States, with a view to improving the recovery at plants using wet concentration, and which again are likely to result in the production of cathodes direct.

On the other hand the present division of work between the refinery and the wire mill is not entirely satisfactory. The present practice of casting wirebars in open molds gives a more or less wrinkled set surface which carries far above the average oxygen content of the body of the bar and which is rolled into the rod and doubtless accounts for many of the defects in copper wire. The possibility of casting vertical billets as is done in steel practice is being seriously discussed, but as no one interest owns both a refinery and a wire mill real coöperation has not yet been attained. It seems likely, however, that eventually some of the refineries will produce wire rod direct or that the wire people will purchase cathodes and further that some central melting plants will be established for handling the large quantities of cathodes that are expected to come upon the market from the various leaching operations.

The 1000 tons per month multiple plant of the Baltimore Copper Works, operating on bullion very high in arsenic, antimony, lead and nickel, has been started and is a very desirable adjunct to the main series plant with its more delicate digestion. The older unit of the Raritan Copper Works has been generally rebuilt. The other plants report practically unchanged capacity.

The basic anode furnaces at the Chrome plant of the United States Metals Refining Company have been kept in operation, principally on foul bullion, and considerable development made in methods of construction. It has been found desirable to use in the hearth magnesite brick fired in the hottest part of the kiln, and even these shrink progressively after they are in place in the hearth. This shrinkage tends to make the bottom leak and in time cause an undesirable amount of metal to collect in the vault underneath the furnace. Solid bottoms were then resorted to and it was found that the temperatures reached were not high enough to injure the magnesite hearth even with the cooling effect of the vault removed. The bottom tie rods expanded unduly, however, and were therefore placed in water-cooled pipes in one furnace and omitted alto-

gether, jackscrews being substituted, in another, both methods giving satisfaction. As the main bottom expanded while the magnesite layer contracted, suitable methods of directing the thrust of the buck stays against the magnesite layer were adopted. A number of the details of construction are shown in Fig. 1, taken from U. S. patent No. 1083719. Metallurgically these furnaces have shown that anodes of the highest grade can be made from very foul bullion and it is likely that a practical method of tin recovery from the concentrated slags made will be worked out. When cathodes are melted in a basic furnace the formation of slag is practically suppressed and a true melting without refining can be nearly if not quite attained.

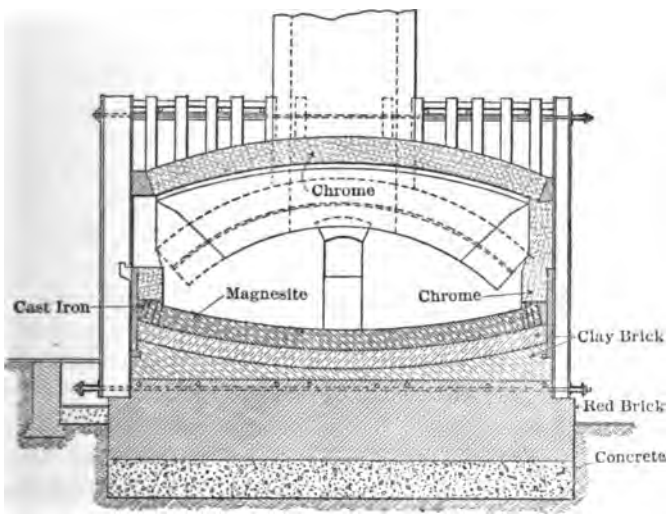


FIG. 37.—Basic lined anode furnace.

There has been a gradual change in all the refineries to larger furnace charges, 12,000,000 lb. a month from a single furnace being now quite usual. There is no physical limitation against very much larger furnaces and the real factor governing size lies in finding the copper to treat. The added economy in these very large units is easily offset by lack of flexibility in meeting fluctuating outputs and it is desirable to have an equipment of three anode and three wirebar furnaces, four of which are kept in service and two in reserve, in order to handle crews, repairs and investment to best advantage. These large charges have been attained in different ways. At the Nichols plant very deep baths are carried; at the Baltimore plant very large furnaces, as refining furnaces go (14 ft. 6 in. × 48 ft.), are used; and at Chrome the refilling process described in last year's article is employed.

In tankhouse work the wedge contact developed at the Perth Amboy plant of the A. S. & R. Co. by Whitehead has been giving a good account of itself. Using the Walker arrangement of tanks, a wedge is cast on top of the anode lug and a slot is cut in the bottom of the corresponding cathode rod in the adjoining tank. The usual three-cornered equalizing bar is omitted and one of the contacts thus eliminated. The anode wedge is made with a 60° angle while the cathode slot is 53°, thereby causing a wedging action which brings the contact surfaces into close union. A large number of tanks have been operating under this system during the past year and a considerable power saving without any practical operating difficulties is reported. A very similar device has been introduced by Antisell at the Raritan Copper Works. Patents have been applied for on both systems.

In the treatment of anode slimes, work on wet processes continues and promising progress has been made, although no wet process is as yet operating. The slimes at the various refineries differ considerably in character, which fact accounts for the variations in methods of treatment. The Cottrell fume precipitation installation at the silver refinery of the Raritan Copper Works has proved a success and this has solved one of the chief problems in connection with the fire process, namely, silver losses. More attention is being paid to the recovery of by-products. A number of plants now recover platinum and palladium in small quantities. The Wohlwill electrolytic process is in use where any considerable quantity of platinum is present, but a chemical process is used when the value lies chiefly in the palladium. Selenium continues to be produced, but under discouraging market conditions. Should additional uses for selenium be discovered, so that 10 or 15 tons a month could be sold, the refineries could turn this out at a very satisfactory price, the present scale of operations being too small for efficient work. A search for radioactive substances in the slimes has given, in general, negative results.

[An article on Hydrometallurgy of Copper by Thomas T. Read will be found in the special chapters at the end of thevolume. EDITOR.]

CRYOLITE

The only occurrence of cryolite that has been developed is situated at Ivigtut, Greenland. The mine belongs to the Oresunds Chemiske Fabriker, Copenhagen, Denmark. Here the product of the mines is treated in part and sold to various consumers or manufactured into chemical products. The production at the mine for the calendar year 1913 amounted to 10,415 metric tons of cryolite. Of this 8451 tons were treated at the works in Copenhagen, and the balance, namely, 1964 tons, was shipped directly from Greenland to the United States.

The preparation for the market and the uses of cryolite are described in MINERAL INDUSTRY, Vol. XX, p. 263.

Formerly cryolite was used in the soda and alum industry and the manufacture of hydrofluoric acid, but now it is used almost entirely for the metallurgy of aluminium and white opalescent glasses and enamels. The Pennsylvania Salt Co. is the sole importer in the United States.

The Department of Commerce reports the following imports, for the fiscal year ending June 30:

	Long Tons.	Value.	Price per Ton.
1911	2007	$47,093	$23.50
1912	2126	48,293	22.70
1913	2519	54,440	21.61

Canada is also an important producer of aluminium and the importations of cryolite for the year 1912 were valued at $56,591. The cryolite is imported practically entirely from the United States.

FELDSPAR

By J. T. Singewald

The production of feldspar in the United States in 1913 amounted to 120,955 short tons valued at $776,551, as compared with 86,572 tons valued at $520,562 in 1912. The principal producing states are California, Connecticut, Maine, Maryland, New York, and Pennsylvania. The great bulk of the imported feldspar comes from the Richardson mine, near Bedford, north of Kingston, Ontario. The Canadian production amounted to 15,935 tons in 1913, valued at $56,841.

FELDSPAR PRODUCTION IN THE UNITED STATES.(a)
(In tons of 2000 lb.)

Year.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1903	13,432	$51,036	28,459	$205,697	41,891	$256,733
1904	19,413	66,714	25,775	199,612	45,188	266,326
1905	14,517	57,976	20,902	168,181	35,419	226,157
1906	39,976	132,643	32,680	268,888	72,656	401,531
1907	31,080	101,816	60,719	457,128	91,799	558,944
1908	18,840	65,780	51,634	362,773	70,474	428,553
1909	31,037	85,421	45,502	316,367	78,707	415,131
1910	24,655	81,965	56,167	419,486	80,822	501,451
1911	28,131	88,394	64,569	490,614	92,700	579,008
1912	26,462	89,001	60,110	431,561	86,572	520,562
1913	45,391	148,549	75,564	628,002	120,995	776,551

(a) Statistics reported by the U. S. Geological Survey for 1911 to 1913; other years the same except for New York.

PRODUCTION OF FELDSPAR BY STATES.
(Crude and Ground. In tons of 2000 lb.)

	1911.(a)		1912.(a)		1913.(a)	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Connecticut	16,497	$73,557	19,075	$94,097	20,288	$115,770
Maine	25,976	246,305	19,091	173,076	38,114	346,779
Maryland	12,694	56,265	9,231	55,998	16,702	82,833
New York (b)	15,652	61,769	22,192	101,525	22,750	119,060
Pennsylvania	132,84	101,090	9,451	71,287	9,629	75,851
Other States	5,449	21,865	7,532	24,579	13,472	36,258
Total	89,552	$560,851	86,572	$520,562	120,955	$776,551

(a) U. S. Geological Survey. (b) New York State Geological Survey.

From the standpoint of production there was little change in the feldspar industry during the year. There have been, however, several

rather interesting developments in connection with the industry in the course of the year, particularly in the Southern states. The U. S. Bureau of Mines published as *Bulletin* 53 a report by A. S. Watts on "Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian States." This bulletin gives descriptions of a number of feldspar deposits in Georgia, North Carolina, and Virginia, and greatly adds to our knowledge of its recurrence in those states. The bulletin is of particular value to the ceramic industry as Mr. Watts, who is a ceramic expert, gives the results of tests made on these feldspars with respect to their behavior in standard porcelain mixtures. The publication of a similar bulletin covering the Northern states is planned by the Bureau of Mines.

A detailed investigation of the feldspar deposits of Georgia was also made by Mr. S. L. Galpin for the Georgia Geological Survey. Mr. Galpin found a few high-grade spars in the state, but these are for the most part rather remote from railroads. There are a number of large deposits more favorably situated with regard to transportation facilities, but of lower grade which are mainly suitable for roofing surfaces, poultry grit, etc. In Georgia, as in other Southern states, the development of the feldspar industry has been retarded through the lack of a nearby market for the product.

In Maryland, the year is notable in offering two new uses for the feldspar of that State. The Earth Products Company of Baltimore erected a mill for making several sizes of poultry grit at a feldspar deposit about 4 miles west of Laurel, a town on the Baltimore and Ohio Railroad between Baltimore and Washington. This is the first attempt to establish this phase of the industry in that section of the country, and it is rather unfortunate that the plant should have been erected so far from the railroad. Under favorable conditions, it ought to be possible to create a considerable demand for poultry grit in that region. There also arose during the year a demand for feldspar for extraction of its potash content. The Spar Chemical Company entered the principal producing district of the State as a purchaser of spar on the basis of its potash content. As the presence of mica- and iron-bearing minerals is not objectionable in material for this use, this market opens up a very profitable outfit for much of the waste material accumulated in connection with the quarrying of spar for pottery purposes, which hitherto has afforded the sole market for the spar of this section. Consequently if this demand continues, it should greatly stimulate the feldspar industry of the state.

The Richardson mine which is the largest producer in Canada and furnishes the great bulk of the spar imported into this country is working a most remarkable deposit of feldspar. The portion of the

pegmatite that is being worked is practically free from mica and other deleterious iron-bearing minerals. Though considerable quartz occurs in the dike, it has for the most part been segregated from the spar so that the quarry is worked in one part as a flint deposit and in another as a feldspar deposit. The feldspar as shot down is practically pure pink potash feldspar which requires little or no hand sorting, the item of greatest expense in most feldspar quarrying being thus eliminated.

The deposits on Maniconagan Bay on the north shore of the St. Lawrence between Esquimeaux Point and Notasquan, which produced a small tonnage in 1911 and 1912, did not contribute to the 1913 output. The pegmatite dikes of that region are unusually large and numerous, and well exposed, extending inward from the coast as ridges of bare rock. On the whole, however, the rock is of low grade. The feldspar is intergrown with too much quartz, and the rock is too fine grained to make possible the elimination of much of the quartz by hand sorting. This fact together with the expense of operating in such a rigorous climate and inaccessible locality will always be serious obstacles to the profitable exploitation of these deposits.

Occurrence and Use.—Commercial feldspar is obtained from pegmatite dikes in which it occurs in association with quartz, mica, and other minerals in minor amounts. The degree of purity required depends to a large extent on the use to which it is to be put. The chief use for feldspar is in the pottery industry. For this use a certain percentage of quartz is allowable in the feldspar, but mica- and iron-bearing minerals are particularly objectionable on account of spotting the ware on burning. A limited quantity of feldspar is used in the manufacture of artificial teeth, scouring soaps, and window washes. For these uses only selected spar is used, and for the latter uses in particular it must be free from quartz. For roofing material and poultry grit, the waste from quarries sorting pottery spar and low-grade deposits carrying considerable quartz, mica, etc., are suitable. A number of processes have been patented for the extraction of potash from feldspar, but the demand for feldspar for this purpose has not yet attained any appreciable proportions. The value of finely ground feldspar as a fertilizer has been experimentally established but has not yet found application in this country.

FLUORSPAR

By Avery H. Reed

The quantity of domestic fluorspar reported to the United States Geological Survey as marketed in 1913 was 115,580 short tons, valued at $736,286, compared with 116,545 short tons, valued at $769,163, in 1912. The average price per ton for the whole country, considering all grades of fluorspar—gravel, lump, and ground—was approximately $6.37 a ton in 1913, compared with $6.60 in 1912, a decrease of 23 cents. Fluorspar was produced in 1913 in six States—Illinois, Kentucky, New Mexico, Colorado, New Hampshire, and Arizona—in the order named.

FLUORSPAR OUTPUT OF THE PRINCIPAL PRODUCING COUNTRIES.
(In metric tons).

Year.	Austria-Hungary.	France.	Germany. (a)	Spain.	United Kingdom.	United States.
1904	7,061	2,047	13,540	(b)	18,451	33,062
1905	7,601	2,434	13,019	(b)	40,079	52,048
1906	7,795	4,218	15,493	70	42,512	37,002
1907	8,779	4,795	16,624	270	50,257	44,884
1908	7,359	5,456	14,925	253	35,257	46,023
1909	8,106	5,725	14,545	246	43,165	62,970
1910	(c)8,000	8,264	17,988	180	62,607	62,970
1911	*Nil.*	9,502	23,073	490	32,100	78,953
1912	.....	.....	21,023	265	29,152	105,712
1913	.....	.....	.....	.....	.....	104,882

(a) Exports. German statistics no longer report production. (b) Not reported. (c) Estimate.

By drawing on the old dump heaps in Derbyshire and on the mines in the County of Durham, the English supply is capable of expansion at any time to meet an increased home or export demand, but the increased output of American fluorspar in the last few years has considerably reduced the shipments from England to the United States, and at present the prices are unremunerative to most shippers notwithstanding the reduction of the United States import duty from $3 to $1.50 per ton.

Illinois.—Over 75 per cent. of the domestic production was made by Rosiclare Lead & Fluorspar mines, and by Fairview Fluorspar and Lead Co., both located at Rosiclare, Hardin County, Ill. And the separate as well as combined production of these two operations was the greatest yet reached by them. Also, Kentucky reached the crest of any previous annual production.

Toward the last of the year, in October, November, and December, the fluorspar industry felt appreciably the retrenching of the iron and steel business, which affords the principal market for fluorspar. More-

over, the general tendency of business depression throughout the country which was manifest late in the year, affected fluorspar shipments that would have swelled the annual production to larger figures. And another factor, which was two times flooding of the Illinois mines by high water of the Ohio river, caused a lessening of the annual production from what it might have been otherwise. Indeed, Rosiclare Lead & Fluorspar mines, with the present state of development might very well have been able to have produced alone as much as the reported production of the entire Illinois-Kentucky district for the year. And Fairview Co.'s mines have reached a state of such substantial development that it is believed they could have produced in 1913, under normal conditions, about 50,000 tons.

Rosiclare and Fairview mines have continued exploitation of their respective fluorspar veins, which are different, without indication of mineralization playing out either in depth or along the strike. The productive levels at Rosiclare during the year were those at 320 and at 420 ft., respectively, although there remained over a considerable tonnage within the stopes at the 220-ft. level, which was hoisted during the year. Lateral development at Rosiclare has extended more than 5000 ft. along the mine levels from the main shaft. Fairview operations include 5 separate shaft installations, all of which were worked more or less during the year. Late in the summer, "Good-hope" shaft, the earliest main shaft, was lost and had to be abandoned on account of irreparable caving. "Blue Diggings" shaft and operation promise hereafter to be Fairview's mainstay; here an excellent new concrete-lined vertical shaft was completed 200 ft. in depth; and during the year Fairview Transportation Co. extended their standard gauge, standard equipped railroad to this operation. This railroad is a service corporation, distinct from Fairview Mining Co., and serves Fairview's different mines to an incline on the Ohio river; and a railway transfer barge serves to transport railway cars to and from Golconda, Illinois.

Kentucky.—Fluorspar mines development in Kentucky, while it has improved over past practices has not reached anything like the substantial and permanent state of the two Illinois mines. The number of fluorspar veins in western Kentucky is legion, and they are typified by lines of strike almost with every point of the compass. But it has come to a matter of belief that best promise for permanent mines or for mines with more than minor possibilities, will be found to accompany large fault-fractures of the district, rather than accompanying smaller faults and fractures, although the latter do have occasional important economic aspects. And it is a fact that fault-fractures with considerable throw, in this fluorspar district, are extensive in length, easily discernible along the strike and so not difficult to locate and prospect. In connection, per-

haps, development lately in Kentucky has settled upon two large fault-fractures, together with nearby and closely associated subsidiary lesser faults and fractures. These two prominent fault systems are the Columbia and the Tabb.

The Columbia fault strikes N. 23° E. across Crittenden and Livingston Counties, Ky., and passes about 5 miles from Marion, Ky. This major fault has a maximum throw of about 900 ft. On this fracture and in one locality two considerable mine developments have been under way during the past year, which are the Sunnybrook ("Keystone") and the Franklin mines, respectively, and adjoining properties.

Sunnybrook mine has sunk the main shaft 300 ft. deep, and finished working out to that depth a single developed lenticular ore-body of fluorspar. The output for the year was 3750 tons of fluorspar, from which was saved and shipped 6300 lb. of lead ore concentrates. On account of the necessity to re-equip the power plant and because of the portending state of business depression, as well as disappointment generally, this mine was closed down and the business of the operators was liquidated at the end of the year; so that Sunnybrook mine is now an abandoned mine.

Franklin sank the main shaft to 300 ft. in depth, and produced about 2000 tons of fluorspar. This property has been operated so far strictly along lines of development rather than in line with outputting. The main working shaft has been sunk vertically about 30 ft. off the vein and in the limestone foot-wall. Cross-cuts have been run to the vein at 100-ft. and afterward at 50-ft. intervals to the bottom of the shaft (300 ft.). At 150-ft. and at 250-ft. levels in the vein have been driven about 150 ft. in both directions from the cross-cuts. The present exploitation has developed a lenticular body of good fluorspar, extending vertically from 100-ft. depth to 300-ft. depth and deeper, and horizontally about 300 ft. in length along the vein. This lens-form shows a maximum width of fluorspar of 6 ft., and will give up an average of 3 ft. It has been calculated that 15,000 tons of fluorspar have already been blocked out.

Some subsidiary veins to the Columbia were also the scene of renewed activity, at two different localities, in 1913. These are Mary Belle mines, located on the Columbia mine property, which won a few hundred tons of fluorspar during the year by contract mining; and Memphis mines property, which was acquired in 1912 by the Aluminium Ore Co. No production was made by the latter on the Memphis property, but some empirical diamond drilling was done to prove up the presence of large ore-bodies of fluorspar. The results of this drilling have not been made public, but it may be predicted that the experience here in diamond drilling has established conclusively what was already suspected, that is,

that on account of the irregular occurrence of lenticular bodies of fluorspar in the fault veins of this district diamond drilling is not satisfactory, unless very many holes are drilled relatively close together so as to cut the vein at different depths in the same vertical horizon. The Memphis mines will not be a producer of fluorspar in 1914, except perhaps by contract mining.

Tabb fault system lies some 8 miles East of Marion, Ky., and crosses the I. C. R. R. near Mexico, Ky. The strike across Crittenden County is N. 72° E., and the maximum throw of the main fault is about 700 ft. This vein system has been explored and prospected throughout a continuous length of more than 3 miles.

The names of the mines and mining properties along the Tabb vein system are, in order from east to west: "Pigmy," on east side of I. C. R. R.; "Mexico," on west side of I. C. R. R.; "Newkirk"; "Ohio Valley" (Blue & Marble); "Hoosier" (Tabb); "Wheatcroft"; "LaRue" (Tabor, Asbridge, and Pogue); "Western Reserve" (Matthews Heirs); "Matthews Bros."; "Parrish"; "American Fluorspar" (Sam Matthews); and "Yandell."

Pigmy mine was the scene of vigorous mining activity in the past year. A subsidiary and parallel vein to the Tabb vein has been developed at this mine, and a lenticular ore-body of exceptionally high-grade fluorspar has been exploited to a depth of 150 ft. Production for the year by Pigmy Mining Co. was 5000 tons of fluorspar, and a minimum carload of lead ore.

Mexico mine and Newkirk mine developments consisted in sinking each a new shaft, for exploiting the main Tabb vein.

Ohio Valley Fluorspar Co., operating Blue & Marble mines under lease, sank the main shaft to 150 ft. in depth, and mined and shipped 1000 tons of fluorspar and 1 car of carbonate zinc ore. Early in the fall operations were closed down.

Hoosier mines were engaged throughout the year in reclaiming the old "Brown & Ward" shaft, which was sunk in 1888 by S. S. Brown and associates, at the time Ohio Valley R. R., now part of I. C. R. R., was built through the region. This was the first development on the Tabb vein, and was instituted in search of lead and zinc ore. The unwatering and reclaiming of this shaft has verified the tradition of plenty of good fluorspar having been found by the former exploiters; so that now the Hoosier Mining Co. has demonstrated that they have the makings of a good fluorspar mine at the old works. A few hundred tons of fluorspar were mined and shipped, and about 100 tons of zinc sulphide ore were mined and stocked.

Wheatcroft Mineral Co. put down a new shaft on their property

during the year, and on the main Tabb fault; also some prospecting was done on the property on a parallel and subsidiary vein. Promising mineralization was shown up in both efforts.

LaRue mines embrace what were formerly Tabor, Asbridge, and Pogue mines, respectively. Operations have been conducted from 2 shafts, the principal one of which has been sunk 250 ft., and from which substantial and systematic mine development has been prosecuted throughout the year, and the results of which have established the presence, in the developed horizons, of several large size lenticular ore-bodies of fluorspar. Production of LaRue Mining Co. was a little over 15,000 tons of fluorspar. A macadamized road wa built in 1913 from LaRue mines to I. C. R. R. siding near Mexico, Ky., a distance of about 2 1/2 miles; and other mines along the line have made connections with this macadamized road.

Western Reserve Mining Co. installed a small steam power plant and sank a shaft about 150 ft. deep. But not being successful in cutting the Tabb vein or any subsidiary veins, about the end of the year operations were closed down, and the business was liquidated.

Sam Matthews mine was being operated under lease by the American Fluorspar Mining Co. In the first 6 months of the year a cleanup of all fluorspar in sight, in stopes, drifts and in fact about the collars of shafts, was made by this interest, by which some 1000 tons of fluorspar were produced, and the mines were abandoned and the company liquidated their business.

Yandell mine is owned in fee by Kentucky Fluorspar Co. A new shaft was sunk on the property during the year, in the zone of fracture of the Tabb vein, and mining was carried on in a subsidiary vein to the Tabb, with the result of producing about 2500 tons of gravel fluorspar of very high grade.

Kentucky Fluorspar Co. maintains a concentrating and grinding plant at Marion, Ky., where fluorspar is concentrated to high grade and is ground. Also lead ore is saved and concentrated. Besides making a production from their own mines, this concern makes a practice of buying fluorspar principally produced under contract from small fluorspar diggings over the district.

R. L. Moore & Co. operates a small grinding plant at Marion, but no concentrating plant, and buys locally mill concentrates as well as very high-grade washed gravel fluorspar for grinding.

Sanders Ore Separating Co. operates a small concentrating plant at Marion, and executes custom milling and ore dressing. This interest mills a good deal of the mine product from LaRue mines. No provision exists at this mill for grinding.

Those that will likely offer fluorspar to the trade in 1914, are the following: Rosiclare Lead & Fluorspar mines; Rogers, Brown & Co., selling agents; Fairview Fluorspar & Lead Co., Hickman, Williams & Co., selling agents; Kentucky Fluorspar Co.; LaRue Fluorspar Co.; Pigmy Mining Co., Avery H. Reed, selling agent; Hoosier Mining Co.; Franklin Mining Co., R. L. Moore & Co.; and Roberts Fluorspar Co.

It is generally believed that there are no strictly lead and zinc ore veins in the Kentucky-Illinois fluorspar district, and the writer holds that view. Nevertheless, it is the belief of the writer that the fluorspar veins of the district do present an opportunity for mining and concentrating zinc ore particularly and also lead ore, that has not so far been appreciated.

Fluorspar deposits are lenticular in the veins of the district, and so present marginal limits of pinching out horizontally and also vertically. Sometimes the lenses of fluorspar deposits are large, and sometimes not of very great dimensions. But the very irregularity of the occurrence of these lenticular bodies of fluorspar in the veins of the district, is a persistent regularity. The fluorspar bodies carry galena in recoverable quantity, but scarcely any zinc. But it is the writer's conviction, after many years of observation and by close study of all accessible mining operations in the district, that the territory of pinches in these fluorspar veins is the locus of mineralization of commercial quantities of sphalerite.

Part of the lead accompaniment of fluorspar is saved in the ordinary milling practice of the district, which does not attempt to recover the lead in particular by specially milling for it; but rather the prevailing mill design and practice is toward the end of concentrating fluorspar and dressing that to a grade satisfactory to the demands of the bulk of the trade; and that trade is the steel industry, which uses more than 75 per cent. of the mine production, and is ordinarily satisfied with specifications for fluorspar of 85 per cent. minimum calcium fluoride and not exceeding 6 per cent. silica. High-grade fluorspar is usually specially selected, and generally is assembled by hand sorting. But ordinary run of mine fluorspar will carry an average of as much as 2 per cent. galena, which could be largely recovered of course if dressed for especially; and the present mill practice recovers not as much as 1 per cent. and possibly about 1/2 per cent. of galena, in dressing fluorspar.

In the pinched ground of our fluorspar veins, that is between, around, and about the lenticular ore deposits of fluorspar, usually zinc mineralization has taken place in the limestone and quartzite wall rocks. This zinc mineralization has emanated from fault planes as the principal loci of deposition, although planes of lesser fractures, jointing planes, even bedding planes within zones of fracture, and planes of brecciation all are also favorable channels for ore formation and enrichment. Zinc

dissemination as well as zinc segregation (the latter arising perhaps mainly by secondary enrichment) has occurred in the rock formations either on one side or on the other or on both sides of planes of fracture or of structure, and disseminated deposits of zinc blende, where specially tested out in this district, have proved usually to extend many feet out into country before fading out, so that it is believed, by the writer anyway, an average value in zinc between 5 and 10 per cent. can be recovered and realized, by handling this disseminated zinc ore on a tonnage basis. Segregated deposits of zinc blende, where encountered, are specially rich, so rich in fact that actual shipments of such ore in lump form have been made from the district, by simply cobbing and without concentrating it; and in 1913, Eclipse Mining Co., operating Commodore mine, concentrated about 500 tons of 60 per cent. zinc blende, by working a bonanza body of segregated zinc blende deposits. Generally it is to be expected that zinc ore mined in this district on a large scale will be desseminated, but it is also reasonable to expect to encounter frequent bonanzas of segregated ore. In both cases the ore will be free milling, have limestone and quartzite gangue and will not present any difficulty in concentrating.

In systematically developing a fluorspar mine it is the natural sequence to extend the regular mine levels *ad libitum* through the pinched territory as well as through the lenticular ore-bodies of fluorspar, and thereby block out the ground for the most economic conditions of mining. And this plan has been followed by Rosiclare Lead & Fluorspar Mines, with the result of proving the orderly occurrence of many lenticular ore-bodies of fluorspar at varied intervals along the levels as well as with depth in the vein. The fluorspar is worked out by overhead stoping and by filled stopes, and the pinched ground is let alone and is not stoped. Therefore possibly Rosiclare has developed a large volume of zinc-mineralized ground, part of which undoubtedly will prove economical to mine for the zinc content. Certainly during the writer's regime of operation of Rosiclare mines, and in prosecuting systematic development of Rosiclare vein, the showing of zinc under the conditions given was very good; and it was planned then to mine some of this zinc, and provision had been made in the new mill constructed by the writer at Rosiclare, to dress some zinc ore; but these features were never tried out, perhaps because the next management of the property did not appreciate the zinc possibilities when the mill was put into operation.

Outside of Rosiclare there has not been any such extensive systematic exploitation of fluorspar mines in the district, the prevailing custom at most other fluorspar properties being to develop from the surface some fortuituous discovery of a defined lenticular ore-body of fluorspar, and when that pinches vertically and horizontally, to make a clean up, rob

the shaft and abandon the mine and find another locality along the strike of the vein where another lenticular fluorspar deposit appears close to the surface and repeat the former operation. Hence the number of old abandoned fluorspar mines in the district is many; and there are thousands of old prospect diggings along the many fluorspar veins, a great many of which have encountered pinched territory in the veins, as shown by the old dumps which often have carried economic quantities of zinc ore and have been treated for the zinc.

However, it has been rarely that any single lenticular deposit of fluorspar has been worked deep enough to encounter a vertical pinch, either in old abandoned mines or in those active at the present time; because usually only comparatively shallow depths have been attained, until lateral pinching has stopped productive operations, water troubles have set in and general unprofitableness has compelled suspension of activities. But where fluorspar deposits have been followed persistently to depth, they have usually given way to a pinched condition of ground.

The possibilities for zinc ore in commercial quantities in this field seem favorable to the writer, and hence the mode of occurrence has been given in detail. The possibilities for zinc at Rosiclare have been stated already. Fairview mines have not practiced as a rule driving through pinches encountered laterally, although "Goodhope" shaft was pushed down 520 ft. deep, and had been in a vertical pinch, showing more or less disseminated zinc mineralization, for the last 100 ft. or more. Rather Fairview operations have consisted in developing discovered separate fluorspar bodies each by a separate shaft. However, the writer has observed at Fairview some very promising zinc ore ground; and at one time the management of Fairview started to assemble specially rich zinc ore, by selection from the picking belt. Indeed, the last and present installation of jigs (Foust) at Fairview Mill, were contracted for and bought strictly on guarantee to separate zinc blende and fluorspar and to recover the zinc ore; which fact demonstrates that Fairview interests at that time believed they had zinc present in commercial quantities. In connection, it should be stated the jigs failed to make the separation of zinc blende and fluorspar; and such a separation is not believed to be commercially possible, where the relative amount of fluorspar present is so much greater than the amount of zinc blende. But it is not the small amount of zinc accompanying fluorspar that seems economically interesting to the writer, and is the commercial quantities of zinc that appear to accompany the pinched regions of fluorspar veins, which zinc will have a limestone and quartzite gangue and so will not be difficult to separate. The matter of zinc recovery at Fairview is then in *statu quo*.

The fluorspar district in Kentucky has been exploited more diligently

for zinc than in Illinois. But efforts have been directed particularly in search of bonanza ore-bodies, which have often been found, but even in successful instances of discovery the interest behind the mining ventures has failed invariably to appreciate how to make systematic mining and concentrating of the high-grade zinc ore profitable. As instances of such discovery and exploitation of bonanza zinc sulphide ore-bodies may be mentioned: Columbia Mine, Nine Acres Mine, Major Clement Mine, old LaRue Mine, Cullen Mine, Mann Mine, Commodore Mine, Ebby Hodge Mine, and Hoosier Mine. And there are many other known and recorded instances where very rich zinc sulphide ore has been encountered in the fluorspar mines, as drifts or levels and shaft sinking have gone out of lenticular deposits of fluorspar into pinched ground. Pinched ground for fluorspar, but enriched ground for zinc sulphide mineralization. Also there are recorded instances of diamond drilling known to the writer, in which extensive cores of rich zinc blende have been obtained.

With limited consumption of and demand for fluorspar, and with promise of only a small yearly increase in the use of and demand for the commodity; and with the condition to face of one single fluorspar mine, Rosiclare, being able alone to produce any year for several years to come, all of the fluorspar required for consumption in the U. S.; also with another operation, Fairview, able now to supply half as much fluorspar yearly as Rosiclare; then the outlook for other fluorspar operators to make money does not seem very bright. Already keen competition for business has brought down considerably quotations named the trade, and it seems as if the bottom in prices has not been yet reached. Moreover, the duty on fluorspar has now been reduced to $1.50 per ton.

It looks like it was going to be a case of the survival of the fittest in the Kentucky-Illinois fluorspar district. Rosiclare and Fairview necessarily have to make a reasonably large production, to keep down costs, because of their large operations and consequent organizations. So that it is apparent only those fluorspar operations in Kentucky that are favorably located, as on and nearby the railroad, and which can get their business systematized to operate within limits of production commensurate with minimum costs, will be able to survive and compete with Rosiclare and Fairview, in the open market.

Prevailing prices holding in 1913 for metallurgical grade were, $5.75 to $6.00 per ton, flat price, f.o.b. Illinois shipping points; and $5.25 to $5.50 per ton, flat price, f.o.b. Kentucky shipping points. Though somewhat better prices on analysis basis were realized from both sides of the Ohio River.

No. 1 lump commanded $12.00 per ton from Illinois points, and $8.00 per ton from Kentucky. No. 1 milled fluorspar concentrates, guaranteed

97 per cent. calcium fluoride and not exceeding 1 per cent. in silica and in total carbonates, fetched $8.00 to $10.00 per ton from Kentucky mills. All prices f.o.b. cars shipping points.

No. 2 lump, which is used by the foundries, commanded $5.75 to $7.00 per ton, f.o.b. shipping points; the lesser figure applying to Kentucky and the greater applying to Illinois.

Acid grade ground brought Illinois interests $15.00 to $17.00 per ton f.o.b. cars shipping points, which prices are understood to cover cost of packages; and similar commodity by Kentucky grinders sold at $11.50 to $12.50 per ton, f.o.b. shipping point, and in bulk shipment, with extra charges for packages.

The largest per cent. of the ground fluorspar prepared is used by the glass industry, and by iron and steel enamelers. Competition has been keen on glass and enamel grade ground, and prices have fluctuated considerably; but $10.00 to $11.00 per ton in bulk f.o.b. shipping point, was a fair average for the year, with extra charge for packages.

FULLER'S EARTH

By E. H. Sellards

The total production of fuller's earth in the United Stated during 1913 was 38,594 short tons. In addition to that produced, there was imported into the United States during the year ending June 30, 1913, 16,866.16 tons, of which 1597 tons valued at $10,359, were unmanufactured or unground, while 15,269.16 tons, valued at $135,229, were manufactured or ground. These importations were under the old rate of duty, which was $1.50 per ton for the unmanufactured earth, and $3 per ton for the manufactured product. During the last half of 1913, July 1 to December 31, under the new tariff rates, which are for unmanufactured earth $0.75 per ton, and for manufactured, $1.50 per ton, there was imported 974 tons unmanufactured valued, at $7660, and 7613 tons manufactured earth, valued at $68,558. These valuations are based on the wholesale price of the product at the port of origin. The actual cost to the consumer includes freight and commission in addition. The exports of fuller's earth from the United States cannot be determined owing to the fact that this product is not listed separate from other clays.

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Production.		Imports.		Years.	Production.		Imports.	
	Sh. Tons.	Value.	Sh. Tons.	Value.		Sh. Tons.	Value.	Sh. Tons.	Value.
1902 ...	14,100	$109,980	15,135	$102,580	1908...	30,517	$270,685	12,279	$ 93,413
1903....	20,693	190,277	17,100	120,670	1909...	29,561	289,000	12,752	101,151
1904....	29,480	168,500	10,221	74,000	1910...	30,857	277,293	16,857	132,545
1905....	25,745	157,776	15,181	105,997	1911...	34,668	335,350	18,224	143,594
1906....	28,000	237,950	14,827	108,696	1912...	32,715	305,522	19,109	145,337
1907 ...	34,039	323,275	14,648	122,221	1913...	38,594	369,750	16,866	145,588

The fuller's earth used in clarifying mineral oils, which includes by far the greater part of that produced in America, is sold at the mine, ground, bolted and sacked for shipment at about $9.50 per ton. That used for refining vegetable oils brings a somewhat higher price, since the earth must be ground to a finer mesh for vegetable than for mineral oil.

Clays having the properties of fuller's earth more or less well developed are widely distributed in the United States and are confined to no particular geological horizon, although the largest known deposits are of

Cenozoic age. By far the greater part of fuller's earth is in the form of a sedimentary deposit which is distinctly stratified, and from which an overburden must be removed in mining. In Arkansas, however, fuller's earth is known that is exceptional in that it is residual, having been formed *in situ* from the disintegration of basaltic dykes.[1] In the United States fuller's earth is known from the following states: Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Massachusetts, Minnesota, Mississippi, New York, South Carolina, South Dakota, Texas and Utah. Of these states, however, only six were actively producing fuller's earth during 1913, as follows: Florida, Georgia, Arkansas, California, Colorado and Massachusetts.

Florida is the chief producer of fuller's earth in the United States. The deposits of this state are found at a definite horizon in the Alum Bluff formation of Upper Oligocene age. Two fuller's earth strata are usually present, each having a thickness of 6 or 8 ft., and separated by sandy or calcareous strata 2 or 3 ft. in thickness. Usually only the upper of these two strata is worked; mining, which is carried on by the open-pit method, starting from the surface outcrop. The deposits being worked are those of Gadsden County in northern Florida, and of Manatee County in southern Florida, the principal output coming at present from the Gadsden County mines.

The fuller's earth of southern Georgia which is worked at Attapulgus near the Florida line represent a northward extension of the Florida deposits. In central Georgia near Macon, however, is found a different type of earth, which according to the Georgia Geological Survey is found in the Claiborne formation of Eocene age. This earth differs in some important respects from that of Florida being used chiefly for vegetable oils, while that from Florida finds its chief use at present in clarifying mineral oils.

The fuller's earth of Arkansas is used chiefly in clarifying vegetable oils. These deposits are mined by underground mining, vertical shafts being sunk from which laterals run to the vein of earth.

The fuller's earth of Colorado is said to be used in bleaching cotton-seed oil while that of Massachusetts is reported as being used in fulling woolen goods.

The fuller's earth of Texas is found in the coastal plains section of the state in the upper part of the Jackson formation. It is used in clarifying vegetable oils and animal fats.

The fuller's earth of California is used, according to the State Mineralogist, principally as a clarifying agent in the refining of crude oils.

The action of fuller's earth in clarifying oils, and the varying behavior

[1] Residual fuller's earth is said to occur also in Saxony where it is found *in situ* derived from gabbro.

of different fuller's earths forms an interesting study on which much yet remains to be done. Porter in 1907 reviewed the different explanations of the clarifying action that had been given and advanced a new theory to explain this property. Porter believes that the clarifying action is due chiefly to colloidal silica present in the clay, and records a series of very interesting tests and analyses which are believed to support this view.[1]

Most fuller's earth gives a taste to the edible oils, and formerly the American earth was rejected by refiners of edible oils on this account, but at the present time methods are known for removing taste and odor from the oil. This is accomplished by blowing dry steam through the refined oil which is heated to a temperature above the boiling point of water.[2] A serious difficulty is the rapid oxidizing action which some fuller's earths have on edible oils. In milling practice air is blown through the filter press to force out the oil remaining in the earth after treatment. With some of the earths the oxidizing action is so rapid that the oil remaining in the earth takes fire, or is liable to take fire at this time. It is to be hoped that this difficulty may be overcome.

Among other striking properties of fuller's earth is the fact that some earths that serve particularly well in refining mineral oils have not been used successfully for vegetable oils and conversely those best suited for vegetable oils are not suited for mineral oils. At the present time the English fuller's earths are being used largely in vegetable oils, while the American fuller's earths are used almost entirely for mineral oils. It is stated, however, in a report recently issued by the Bureau of Mines[3] that the United States has fuller's earth far better suited for refining edible oils than any imported, and that to assure the almost universal use of this earth by American refiners there is required only a careful and intelligent control of the preparation of the output and its application to the bleaching of oils.

List of Fuller's Earth Producers in the United States, 1912 and 1913:

	Office	Location of Mine
Adams and Bemis.,		Murfreesboro, Arkansas.
American Clay Co.,		Akran, Colorado.
American Meat Packers' Asso.,	Chicago, Ill.	Fairplay, Arkansas.
American Refiner's Earth Co.,	Benton, Ark.	Klondike, Arkansas.
Argyla Fuller's Earth Co.,		Argyle S.D.
Arizona Earth Products Co.,		Benson Ariz.
Atlantic Refining Co.	Philadelphia, Pa.	Ellenton, Florida.
Commercial Pulverizing Co.,	Houston, Texas.	Fayette & Burleson Counties.
Eight Oil Co.,		Bakersfield, California.

[1] Properties and Tests of Fuller's Earth, by John T. Porter, *Bull.* 315, U. S. Geol. Surv., pp. 268–290, 1907.
[2] *Bull.* 71, U. S. Bureau of Mines, 1913.
[3] Fuller's Earth, by Charles L. Parsons, Bureau of Mines, *Bull.* 71, 1913.

	Office	Location of Mine
Floridin Co.	Warren, Pa.	Quincy, Florida.
Florida Fuller's Earth Co.,		Ellenton, Florida.
Fuller's Earth Co.,		Midway, Florida.
Fuller's Earth Co.,	Houston, Tex.	Somerville, Texas.
Fuller's Earth Union (Ltd.),	London, Eng.	Fairplay, Arkansas.
General Reduction Co.,	Atlanta, Ga.	Pikes Peak, Georgia.
J. E. & R. N. Farnsworth Co.,		Lancaster, Mass.
John Olsen,		Klondyke, Arkansas.
Lester Clay Co.,	Jacksonville, Fla.	Attapulgus, Georgia.
National Fuller's Earth Co.,		Salters Depot, S. C.
Palmetto Kaolin Co.,		South Carolina.
South Dakota Fuller's Earth Co.,		Rapid City, S.D.
Western Fuller's Earth Co.,		Vacaville, California.

GOLD AND SILVER

By M. W. von Bernewitz

Although the gold production of the year 1912 showed an increase of 2.2 percent over the previous year, yet it was noted that the rate of increase in gold production was steadily declining, and for 1913 we find that the rate of increase has not only been brought to a halt, but that the total output has actually diminished materially, the decrease amounting to about $21,000,000 compared with 1912. This was due to reduced yields from the Transvaal, where a strike interfered with regular mining, two mines were shut down, there was a scarcity of labor, and lower grade ore was extracted; the United States, where the Goldfield Consolidated worked poorer though profitable ore; and mines in Colorado, South Dakota, and Utah yielded less; the further decline in Australasia, although not at such a great rate as in previous years, Western Australia arresting this downward movement somewhat; and in Mexico, where the continued revolution has shut down many mines and smelters, with no apparent better conditions in sight. Russia had an increase of about $2,400,000 compared with 1912, mostly from placer mining; the Indian mines, at Kolar, gradually increase their output in spite of depth; and in Canada, the gold mines at Porcupine and adjoining districts, those of British Columbia, and the Klondike gave better returns. Details of the principal mines of the various countries will be given in another portion of this chapter.

Accurate statistics of the world's production of gold are never available, but the annual estimates are close enough for all practical purposes. Exact figures are of no particular use in any event, for the principal value of statistics lies in the indication of general tendencies. The table showing the world's production of gold for several years past is of interest, for it shows the great variations in production and the obvious tendency toward a gradual diminution.

Commercial Movement of Gold

Although the past year was a highly prosperous one for trade, it was memorable for a combination of circumstances which cast a gloom on markets generally. These include the revolutions in China and Mexico,

war in the Balkans, and uncertainty as to the military movements of European powers. Prudence demanded the careful handling of monetary resources, resulting in an unusually high rate for money during the second

GOLD PRODUCTION OF THE WORLD. (a)

Countries.	1911.			1912.			1913.		
	Oz. Fine.	Kilograms	Value.	Oz. Fine.	Kilograms	Value.	Oz. Fine.	Kilograms	Value.
America, North:									
United States	(b) 4,687,053	145,777	$96,890,000	(b) 4,437,561	138,008	$91,685,134	(b) 4,271,940	133,080	$88,301,02
Canada	(a) 473,201	14,719	9,781,077	(a) 607,617	18,897	12,559,443	(a) 784,525	24,420	16,216,13
Mexico	(g) 1,412,483	43,933	29,196,026	(g) 1,096,058	34,092	22,655,519	(e) 996,613	30,870	20,500,00
Central America	(b) 165,457	5,146	3,420,000	(e) 175,000	5,442	3,617,250	(e) 146,608	4,560	3,030,40
America, South:									
Argentina	(b) 13,979	435	289,000	(e) 14,467	450	299,043	(e) 51,910	160	107,30
Bolivia	(a) 1,082	33	22,370	(a) 1,117	35	23,098	(e) 84,692	263	175,00
Brazil	(g) 109,949	3,420	2,272,631	(g) 102,380	3,184	2,116,200	(e) 172,743	5,390	3,570,60
Chile	(b) 17,661	549	365,058	(e) 19,290	600	398,724	.....	.....	.....
Colombia	(b) 153,241	4,776	3,167,800	(e) 160,750	5,000	3,322,700	(e) 143,768	4,475	2,971,70
Ecuador	(b) 13,389	416	276,800	(e) 12,860	400	265,816	(e) 19,666	610	406,50
Guiana, British	(a) 46,387	1,443	958,819	(a) 42,563	1,324	879,777	(e) 42,564	1,324	879,00
Guiana, Dutch	(a) 36,500	1,140	754,450	(a) 13,948	434	288,410	(a) 27,640	860	571,10
Guiana, French	(a) 147,536	4,589	3,049,569	(e) 144,675	4,500	2,990,430	(e) 147,585	4,594	3,050,60
Peru	(b) 22,055	686	455,900	23,823	741	492,421	(e) 23,328	740	492,20
Uruguay	(b) 3,422	106	70,600	(e) 3,215	100	66,454	(e) 5,370	165	111,00
Venezuela	(a) 16,238	522	335,650	(e) 17,682	550	365,497	(e) 30,164	939	623,50
Europe:									
Austria	(a) 6,591	205	134,840	(e) 6,430	200	132,908	(e) 98,873	3,060	2,043,20
France	(a) 87,641	2,726	1,812,077	(e) 96,450	3,000	1,993,620	(e) 87,668	2,728	1,812,10
Hungary	(a) 102,687	3,194	2,125,241	(e) 102,880	3,200	2,126,528	.....	.....	.....
Germany	(a) 159,692	4,967	3,300,845	(e) 160,750	5,000	3,322,700	(e) 3,778	117	78,10
Italy	(a) 829	26	17,119	(e) 804	25	16,614	(e) 532	16	11,00
Russia	1,465,693	45,589	30,295,881	(a) 1,395,882	43,562	28,852,881	(e) 1,073,972	33,430	22,199,00
Portugal	(a) 129	4	2,658	(a) 129	4	2,658	(e) 111	4	2,30
Sweden	(a) 354	11	7,310	(a) 997	31	19,601	(e) 982	30	20,30
Turkey	(b) 1,447	45	29,905	(e) 322	10	6,645	(e) 24	¾	50
Servia	.....	.....	.....	.....	.....	.....	(e) 12,148	378	251,10
United Kingdom	(a) 354	11	7,310	(e) 14	½	289	(a) 1,340	40	27,80
Africa:									
Congo	29,128	906	602,073	(e) 30,237	940	625,000	} (e) 98,916	3,064	2,044,60
Madagascar	(a) 91,627	2,850	1,893,940	(e) 96,760	3,009	2,000,000			
Rhodesia	(a) 628,521	19,547	12,989,763	(a) 642,807	19,991	13,286,821	(a) 674,198	20,980	13,935,68
Transvaal	(a) 8,020,422	249,469	165,782,032	(a) 9,131,558	283,991	188,749,317	(a) 8,794,824	273,930	181,889,01
West Coast	(a) 251,968	7,836	5,208,183	(a) 342,045	10,638	7,070,071	(a) 379,608	12,110	7,846,56
Asia:									
Borneo, British	(a) 71,807	2,233	1,484,250	(e) 80,375	2,500	1,661,350			
British India	.....	.....	.....	.....	.....	.....	(a) 587,518	18,289	12,144,22
China	(b) 160,344	4,987	3,314,600	(e) 160,750	5,000	3,322,700	(e) 176,526	5,510	3,658,90
E. Indies, British							(e) 65,360	2,036	1,352,00
E. Indies, Dutch	(b) 163,852	5,096	3,387,100	(e) 160,750	5,000	3,322,700	(e) 163,860	5,100	3,387,10
India	(a) 526,622	16,380	10,899,756	(a) 534,543	16,627	11,063,695			
Indo-China							(e) 3,614	110	74,70
Formosa	53,273	1,657	1,100,877	(e) 53,048	1,650	1,096,491			
Japan	(a) 150,541	4,682	3,111,675	(e) 160,000	4,976	3,307,200	(e) 216,110	6,727	4,467,00
Korea	(g) 315,422	9,810	6,519,773	(g) 243,022	7,586	5,041,867	(e) 138,006	4,296	2,852,6
Malay States	(a) 8,414	262	174,017	(a) 12,866	400	265,940	.....	.....	.....
Siam	.....	.....	.....	.....	.....	.....	(e) 2,733	85	56,50
Australasia (c)	(e) 2,877,295	89,484	58,322,770	(a) 2,636,391	81,992	54,492,402	(a) 2,551,303	79,420	52,736,43
Other Countries	(e) 25,000	778	516,750	(e) 25,000	778	516,750	.....	.....	.....
Total	22,519,286	700,445	$464,346,495	22,948,716	713,867	$474,322,664	22,081,160	682,911	$453,887,50

(a) Official statistics of the country. (b) United States Mint Report. (c) Six States and Ne Zealand. (e) Estimated. (g) Exports.

half of 1913, and a consequent decrease in speculative activity. Nevertheless, the effect of these factors on gold, the basis of international finance, cannot be said to have been very apparent, for with the exception of considerable exports from the United States, in order to pay

for securities returned from Europe, no remarkable movements of gold took place as a result of the widespread unrest.

In 1912, India absorbed £27,600,000 in gold, but the net imports in 1913 were only £18,000,000. Reserves of gold held by the Indian government are £25,642,000, against £24,820,000, and £13,260,000 at the end of the last 3 years.

The decrease in the production of gold occurred at a time when there was an acute demand for it in almost all commercial countries. In Europe, England, France and Germany, were alike active bidders for gold during a large part of 1913, France being the most urgent. Gold shipments from South Africa and Australia were quickly absorbed in the London market. The premiums offered were sufficient to draw more gold from the United States than it received, although there was a large trade balance (about $700,000,000) in favor of this country all through the year. In part, this demand was due to the activity of trade, but in part also to the disturbed political conditions in eastern Europe and the absorption and destruction of capital by the Balkan war. The

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493–1850.
According to Dr. Adolph Soetbeer.

Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.	Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520	162,400	1,316,000	8.1	10.75	1701–1720	256,400	7,112,000	27.7	15.21
1521–1544	171,840	2,164,800	12.6	11.25	1721–1740	381,600	8,624,000	22.6	15.08
1545–1560	136,160	4,985,600	36.6	11.30	1740–1760	492,200	10,662,900	21.7	14.75
1561–1580	136,800	5,990,000	43.8	11.50	1761–1780	414,100	13,054,800	31.5	14.73
1581–1600	147,600	8,378,000	56.8	11.80	1781–1800	355,800	17,581,200	49.4	15.09
1601–1620	170,400	8,458,000	49.6	12.25	1801–1810	177,780	8,941,500	50.3	15.61
1621–1640	166,000	7,872,000	47.4	14.00	1811–1820	114,450	5,407,700	47.2	15.51
1641–1660	175,400	7,326,000	41.8	14.50	1821–1830	142,160	4,605,600	32.4	15.80
1661–1680	185,200	6,740,000	36.4	15.00	1831–1840	202,890	5,964,500	29.4	15.75
1681–1700	215,300	6,838,000	31.8	14.97	1841–1850	547,590	7,804,150	14.3	15.83

GOLD PRODUCTION OF THE WORLD, 1851–1912.

Year.	Value.	Year.	Value.	Year.	Value.	Year.	Value.
1851....	$67,600,000	1867...	$104,000,000	1883...	$95,400,000	1899...	$311,505,947
1852....	132,800,000	1868...	109,700,000	1884...	101,700,000	1900...	258,829,703
1853....	155,500,000	1869...	106,200,000	1885...	108,400,000	1901...	260,877,429
1854....	127,500,000	1870...	106,900,000	1886...	106,000,000	1902...	298,812,493
1855....	135,100,000	1871...	107,000,000	1887...	105,775,000	1903...	329,475,401
1856....	147,600,000	1872...	99,600,000	1888...	110,197,000	1904...	349,088,293
1857....	133,300,000	1873...	96,200,000	1889 ..	123,489,000	1905...	378,411,754
1858....	124,700,000	1874...	90,800,000	1890...	118,848,700	1906...	405,551,022
1859....	124,900,000	1875...	97,500,000	1891 ..	130,650,000	1907...	416,101,396
1860....	119,300,000	1876 ..	103,700,000	1892...	146,292,600	1908...	443,355,856
1861....	113,800,000	1877...	114,000,000	1893...	158,437,551	1909...	458,424,058
1862....	107,800,000	1878...	119,000,000	1894...	182,509,283	1910...	453,766,523
1863....	107,000,000	1879...	109,000,000	1895...	198,995,741	1911...	464,346,495
1864....	113,000,000	1880...	106,600,000	1896...	211,242,081	1912...	474,322,664
1865....	120,200,000	1881...	103,102,000	1897...	237,833,984	1913...	453,887,567
1866....	121,000,000	1882...	102,000,000	1898...	287,327,833	.....	.....

SILVER PRODUCTION OF THE WORLD, 1856–1912.

Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.
1856–1860 .	4,534,950	1883....	2,746,123	1894.....	5,205,065	1905.....	5,638,183
1861–1865 .	5,505,575	1884....	2,788,727	1895.....	5,667,691	1906.....	5,683,947
1866–1870..	6,695,425	1885....	2,993,805	1896.....	5,496,178	1907.....	5,704,083
1871–1875 .	9,847,125	1886....	2,902,471	1897.....	5,663,304	1908.....	6,612,304
1876.....	2,323,729	1887....	2,990,398	1898.....	5,575,336	1909.....	7,069,656
1877.....	2,388,612	1888....	3,385,606	1899.....	5,529,024	1910.....	471,663
1878.....	2,551,364	1889....	3,901,809	1900.....	5,599,216	1911.....	7,906,446
1879.....	2,507,507	1890....	4,180,532	1901.....	5,438,443	1912.....	7,806,516
1880.....	2,499,998	1891....	4,479,649	1902.....	5,121,469	1913.....	.....
1881.....	2,592,639	1892....	4,985,855	1903.....	5,386,044	.....	.....
1882.....	2,769,065	1893....	5,339,746	1904.....	5,669,124	.....	.....

demand for gold from India was a little less than in 1912, when it showed such a remarkable increase.

Germany absorbed a good deal of gold in March, May, June, and September, while Russia was a buyer in October and November. Imports of bar gold to Great Britain in 1913 were £47,137,000 from Africa, India, Australasia, South and Central America, and other smaller countries. Exports totaled £25,477,000 to India, European countries, and £600,000, included in the total, to the United States.

The United States exported gold worth $88,601,200 and imported $63,961,609 in 1913, against $46,768,138 and $55,151,765 respectively in 1912. The banks of Europe on December 31, 1913, held gold amounting to $2,779,540,000, compared with $2,513,807,000 at the end of the previous year, an increase of $265,733,000. The Bank of Russia was the largest holder, reporting $836,000,000, which includes government balances. The Bank of France held the largest commercial balance, $701,536,000. The treasury department of the United States estimates the total gold in the country at $1,917,498,400.

The Silver Market

During the year 1913, prices were dominated by the operations of the Indian Government, but the market was erratic and had a downward tendency. Its acquirement of over £6,000,000 in 1912 had imparted strength to the market, which was continued into January, 1913, by a further purchase of £1,000,000, according to Samuel Montagu & Co. of London. Prices on January 7 were the highest for the year, being 29 3/8d. per ounce in London. The average in London and New York in January was 28.993d. and 63.01 cents respectively. On account of disappointment in negotiating the Chinese government loan, prices fell away in February. Near the end of that month, a "squeeze" for delivery in Bombay was manipulated by the Indian Specie Bank, during which operators caught "short" were mulcted 7 per cent. or 2d. (4 cents) on the London price.

"Bear" sales depressed the market in March, forcing almost the lowest figure for the year, 26 1/16d. ($0.52). From this point a steady recovery set in, owing to better news from the Balkans, and the hopeful negotiations of the five powers with the Chinese loan. This was floated on May 22, and silver had advanced a fortnight previous to this transaction to 28 3/16d. ($0.56) The loan was followed by a dull market, and prices sagged. Supplies were scanty, and a more or less constant demand arose from China in July, improving matters. During the next 3 months the Indian Government's transactions were felt, there being about £4,500,000 of silver purchased.

Owing to steady withdrawal of all supplies over ordinary market demands, the cash price went to 28 11/16d. ($0.57) on September 22. From this date the tendency of prices was downward, and it became evident that trouble was in sight. The Indian Specie Bank had been able to dispose of part of its colossal holding to the Indian government on very favorable terms. The Bank was doubtless more unable than unwilling to sell more before it became too late. Heavy "bear" sales hastened a fall in prices, and on November 29 the Bank failed.

At the end of 1913, prices were 26.720d. in London, and 57.73 cents per ounce in New York.

AVERAGE PRICE OF BAR SILVER IN LONDON, 1833–1912.
(In pence per standard ounce, 0.925 fine.)

Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.
1833.	59.1875	1843	59.1875	1853	61.5000	1863	61.3750	1873	59.2500	1883	50.5625	1893	35.6250
1834.	59.9375	1844	59.5000	1854	61.5000	1864	61.3750	1874	58.3125	1884	50.6250	1894	28.9375
1835.	59.6875	1845	59.2500	1855	61.3125	1865	61.0625	1875	56.8750	1885	48.6250	1895	29.8750
1836.	60.0000	1846	59.3125	1856	61.3125	1866	61.1250	1876	52.7500	1886	45.3750	1896	30.7500
1837.	59.5625	1847	59.6875	1857	61.7500	1867	60.5625	1877	54.8125	1887	44.6250	1897	27.5625
1838.	59.5000	1848	59.5000	1858	61.3125	1868	60.5000	1878	52.5625	1888	42.8750	1898	26.4375
1839.	60.3750	1849	59.7500	1859	62.0625	1869	60.4375	1879	51.2500	1889	42.6875	1899	27.4375
1840.	60.3750	1850	60.0625	1860	61.6875	1870	60.5625	1880	52.2500	1890	47.6875	1900	28.2500
1841.	60.0625	1851	61.0000	1861	60.8125	1871	60.5000	1881	51.6875	1891	45.0625	1901	27.1875
1842.	59.4375	1852	60.5000	1862	61.4375	1872	60.3125	1882	51.6250	1892	39.8125	1902	24.0900

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1903.	21.98	22.11	22.49	23.38	24.89	24.29	24.86	25.63	26.75	27.89	27.01	25.73	24.75
1904.	26.423	26.665	26.164	24.974	25.578	25.644	26.760	26.591	26.591	26.349	26.760	27.930	26.399
1905.	27.930	28.047	26.794	26.108	26.664	26.910	27.160	27.822	28.528	28.637	29.493	29.977	27.839
1906.	30.113	30.464	29.854	29.984	30.968	30.185	30.113	30.529	31.483	32.148	32.671	32.003	30.868
1907.	31.769	31.852	31.325	30.253	30.471	30.893	31.366	31.637	31.313	28.863	27.154	25.362	30.188
1908.	25.738	25.855	25.570	25.133	24.377	24.760	24.514	23.858	23.877	23.725	22.933	22.493	24.402
1909.	23.843	23.706	23.227	23.708	24.343	24.166	23.519	23.588	23.743	23.502	23.351	24.030	23.706
1910.	24.154	23.794	23.690	24.483	24.797	24.651	25.034	24.428	24.567	25.596	25.680	25.160	24.670
1911.	24.865	24.081	24.324	24.595	24.583	24.486	24.286	24.082	24.209	25.594	25.649	25.349	24.592
1912.	25.887	27.190	26.875	27.284	28.038	28.215	27.919	28.375	29.088	29.299	29.012	29.320	28.842
1913.	28.993	28.356	26.669	27.415	27.794	27.195	27.074	27.335	27.985	28.083	27.262	26.720	27.573

AVERAGE PRICE OF SILVER IN NEW YORK.

(In cents per fine ounce.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1904....	57.055	57.592	56.741	54.202	55.430	55.673	58.095	57.806	57.120	57.923	58.453	60.563	57.221
1905....	60.690	61.023	58.046	56.600	57.832	58.428	58.915	60.259	61.695	62.034	63.849	64.850	60.352
1906....	65.288	66.108	64.597	64.765	66.976	65.394	65.105	65.949	67.927	69.523	70.813	69.050	66.791
1907....	68.673	68.835	67.579	65.462	65.981	67.090	68.144	68.745	67.792	62.435	58.677	54.565	65.327
1908....	55.678	56.000	55.365	54.505	52.795	53.663	53.115	51.683	51.720	51.431	49.647	48.769	52.864
1909....	51.750	51.472	50.468	51.428	52.905	52.538	51.043	51.125	51.440	50.923	50.703	52.226	51.502
1910....	52.375	51.534	51.454	53.221	53.870	53.462	54.150	52.912	53.295	55.490	55.635	54.428	53.486
1911....	53.795	53.222	52.745	53.325	53.308	53.043	52.630	52.171	52.440	53.340	55.719	54.905	53.304
1912....	56.260	59.043	58.375	59.207	60.880	61.290	60.654	61.606	63.078	63.471	62.792	63.365	60.835
1913....	62.938	61.642	57.870	59.490	60.361	58.990	58.721	59.293	60.640	60.793	58.995	57.760	57.791

SILVER PRODUCTION OF THE WORLD.

Country.	1912.			1913.		
	Oz. Fine.	Kilograms.	Value. (*d*)	Oz. Fine.	Kilograms.	Value. (*d*)
North America:						
United States.....	(*b*) 62,369,903	1,939,966	$37,920,899	(*b*) 67,601,111	2,109,060	$39,067,556
Canada.....	(*a*) 31,931,710	993,210	19,425,656	(*a*)31,750,618	989,110	18,984,012
Mexico.....	(*g*) 82,506,963	2,566,313	47,605,160	.....	.....	.....
Central America..	(*e*) 1,733,142	53,908	1,000,000	.....	.....	.....
South America:				.....	.....	.....
Argentina.....	(*e*) 208,975	6,500	120,575	.....	.....	.....
Bolivia.....	(*a*) 3,984,639	123,939	2,299,068	.....	.....	.....
Chile.....	(*e*) 868,050	27,000	500,850	.....	.....	.....
Colombia.....	(*e*) 835,900	26,000	422,300	.....	.....	.....
Ecuador.....	(*e*) 22,505	700	12,985	.....	.....	.....
Peru.....	(*e*) 9,323,500	290,000	5,379,500	.....	.....	.....
Europe:				.....	.....	.....
Austria.....	(*e*) 1,607,500	49,000	927,500	1,750,053	54,434	1,068,778
Belgium(*f*).....	(*a*) 9,000,875	279,965	4,993,351	8,164,171	253,940	.....
France.....	(*e*) 1,446,750	45,000	834,750	.....	.....	.....
Germany.....	(*e*) 14,146,000	440,000	8,162,000	.....	.....	.....
Greece.....	(*e*) 803,750	25,000	463,750	.....	.....	.....
Hungary.....	(*e*) 353,650	11,000	204,050	.....	.....	.....
Italy.....	(*e*) 417,950	13,000	241,150	.....	.....	.....
Norway.....	302,210	8,400	174,370	271,957	8,549	.....
Portugal.....	(*a*) 149,369	4,646	86,183	.....	.....	.....
Russia.....	(*e*) 321,500	10,000	185,500	.....	.....	.....
Spain.....	(*e*) 4,179,500	130,000	2,411,500	.....	.....	.....
Sweden.....	(*a*) 30,928	962	17,845	.....	.....	.....
Turkey.....	(*e*) 964,500	30,000	556,500	.....	.....	.....
United Kingdom..	(*e*) 482,250	15,000	278,250	457,135	14,240	274,220
Asia:				.....	.....	.....
Dutch Indies.....	(*e*) 462,960	14,400	267,120	.....	.....	.....
Formosa.....	(*e*) 61,085	1,900	35,245	.....	.....	.....
Japan.....	(*e*) 4,501,000	140,000	2,597,000	.....	.....	.....
Africa.....	(*e*) 1,125,250	35,000	649,250	.....	.....	.....
Australasia.....	(*a*) 16,112,054	501,152	9,712,935	18,854,870	.....	.....
Other countries...	(*e*) 725,000	22,555	356,820	.....	.....	.....
Total.....	250,979,368	7,804,516	$147,902,008	.....	.....	.....

(*a*) Official statistics of the country. (*b*) United States Mint Report. (*e*) Estimated. (*d*) The value of silver unless specifically reported in the official statistics of the country is taken as $0.492 in 1911, and $0.577 in 1912 and $0.578 in 1913. (London quotations.) (*f*) Largely from imported ores and may duplicate production to some extent. (*g*) Exports.

Imports of silver to England in 1913 were 114,800,000 oz., including 88,300,000 from the United States and Mexico, and 19,600,000 oz. from Canada. The freight on silver from Canada to England was raised during the year by the shipping companies, and the metal started to move to

New York, and those interested thought that this place would become a center for silver transactions. But later on the freight was reduced to the old rate, and silver again flows to London. Exports from England were 117,000,000 oz., including 78,000,000 oz. to India, 14,700,000 oz. to Germany, and 6,000,000 oz. to China. The net imports to India on private account were 35,052,341 oz., and 255,814,141 oz. since 1908.

Imports of silver into the United States were $36,062,674, and exports $63,620,828.

Gold and Silver Mining in the United States

The gold-mining industry of the United States was generally normal in 1913, according to H. D. McCaskey, of the U. S. Geological Survey, but early figures indicate the smallest output since 1905, when it was $88,180,700. Preliminary estimates of the Geological Survey and Bureau of the Mint indicate a domestic gold production of $88,301,023, a decrease of $5,150,477 from the final figures for 1912.

The decrease is to be ascribed mainly in declines in the output from Alaska, Nevada, South Dakota, and Utah. In Alaska the net decrease was over $1,500,000.

PRODUCTION OF GOLD IN THE UNITED STATES. (a)

States.	1910.		1911.		1912.		1913.	
	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)
Alabama	1,593	$32,900	890	$18,400	855	$178,674	390	$8,062
Alaska	787,148	16,271,800	806,179	16,665,200	842,108	17,39,943	715,211	14,783,512
Arizona	165,113	3,413,200	170,348	3,521,400	159,890	3,303,504	183,988	3,803,039
California	988,854	20,441,400	964,041	19,928,500	967,443	19,988,486	972,686	20,105,447
Colorado	922,967	20,526,500	925,839	19,138,800	909,519	18,791,710	890,664	18,420,031
Georgia	1,161	24,000	1,548	32,000	478	9,881	478	9,881
Idaho	50,113	1,035,900	65,688	1,357,900	63,110	1,303,917	66,115	1,366,605
Montana	179,974	3,720,400	176,554	3,649,700	156,589	3,235,287	148,921	3,078,202
Nevada	913,015	18,873,700	875,438	18,096,900	645,253	13,331,680	594,055	12,279,131
New Mexico	23,084	477,200	36,847	761,700	29,280	604,961	40,836	844,086
North Carolina	3,122	64,500	3,478	71,900	6,910	142,760	5,391	111,442
Oregon	32,960	681,400	30,679	634,200	30,531	630,801	66,327	1,370,987
South Carolina	1,827	37,800	972	20,100	754	15,587	96	1,985
South Dakota	260,266	5,380,200	359,402	7,429,500	377,311	7,795,680	348,210	7,197,498
Tennessee	136	2,800	576	11,900	478	9,881	373	7,711
Texas	18	400	189	3,900	492	10,170	6	120
Utah	208,627	4,312,700	217,020	4,486,200	211,845	4,376,971	164,494	3,400,103
Virginia	44	900	150	3,100	424	8,755	170	3,514
Washington	38,992	806,000	40,635	840,000	13,796	285,044	33,479	692,021
Wyoming	199	4,100	1,030	21,300	1,108	22,884	1,475	30,491
Other States	283	5,900	5	100	15	310	.....	.....
Total	4,649,496	$96,113,700	4,677,508	$96,692,700	4,418,139	$91,284,886	4,233,365	$87,512,868
Porto Rico	50	1,000	97	2,000	.....	.....	54	1,116
Philippine Islands	7,471	154,400	9,448	195,300	19,372	400,248	38,076	787,039
Total	4,657,017	$96,269,100	4,687,053	$96,890,000	4,437,561	$91,685,134	4,271,495	$88,301,023

(a) The statistics in this table are reported by the Director of the Mint, those for 1913 being the preliminary figures (subject to revision). (b) At $20.67 per ounce.

American mining companies that publicly announce their dividends paid $76,215,014 in 1913, compared to $68,776,540 in 1912. Canadian and Mexican companies paid $21,501,930 in 1913 and $21,212,929 in 1912, according to the *Engineering and Mining Journal.*

United States metallurgical and holding companies connected with the mining industry paid $99,529,253 in 1913, as compared with $91,948,280 in 1912. Although these are not all gold and silver companies, yet the latter contribute largely to the total.

Alaska.—Owing to a dry summer, a storm at Nome, and a drop in the output of the Fairbanks placer mines, this territory had a reduced gold yield in 1913. At the same time, there was considerable activity throughout the country. The output was estimated at $15,450,000 against $17,145,951 in 1912. The total to date is approximately $228,200,000. The silver output, largely a by-product of gold and copper, was worth $220,000 last year, against $316,839 in 1912, according to Alfred H. Brooks of the U. S. Geological Survey.

Placer Mining.—It is estimated that 35 dredges were operated in Alaska in 1913, and that these produced gold to the value of about $2,650,000, as against $2,200,000 in 1912. There were also 6 or 8 dredges which, for one reason or another, were not operated in 1913. A number of others are under construction or planned for.

About 15 placer mines were operated in the Kenai peninsula, but work was hampered by low-water conditions. Most of these were only very small operations, but one relatively large hydraulic plant was at work on Resurrection creek, and two smaller ones on Bear creek. Prospecting dredging ground on Kenai river was continued. The hydraulic plant on Crow creek, north of Turnagain arm, was operated throughout the open season.

About 150 placer mines were operated in the Fairbanks district for a whole or a part of 1913. These gave employment to about 1000 men in winter and 3000 in summer. Preliminary estimates indicate that the value of the placer gold production was about $3,450,000.

As in the other Yukon camps, the shortage of water greatly hampered mining operations in the Iditarod-Innoko district. This condition, together with the fact that certain claims were not worked because they were being combined into large holdings for the purpose of exploiting in a large way, led to a great curtailment of gold output compared with the previous year. Preliminary estimates indicate that the value of the gold production from the Iditarod-Innoko districts was $2,000,000, of which about $200,000 is to be credited to the latter area. There was some prospecting of lode claims, but the cost of mining is so great

that few have been attracted to quartz development. In the Iditarod region the largest production came from the mines on Otter and Flat creeks, but mining was also done on Happy, Willow, Moore, and Chicken creeks and in Glen gulch. The dredge on Flat creek was operated throughout the summer, and plans have been made to install a boat on Otter creek. The chief activity in the Innoko district in 1913 was on Little creek, where a considerable area of rich new placer ground was discovered. Work was continued on Spruce and Ganes creeks. Ophir creek is worked out and practically abandoned. Yankee creek ground has been acquired by a dredging company, and mining is at a standstill pending the construction of a dredge.

Thirty-one dredges were operated for a part or the whole of the summer, on the Seward Peninsula, with an estimated gold recovery of a value of $1,800,000. These dredges had a combined daily capacity of 33,300 cu. yd. Four new dredges were erected in 1913, and several others were in course of construction. Others are contemplated. In addition to 31 operated, there were 6 dredges idle in 1913. Of the dredges engaged in productive mining, 11 were in the Nome, 11 in the Solomon, 5 in the Council, 1 in the Kougarok, and 4 in the Fairhaven, and 1 in Port Clarence district. Of other than dredge mining there was very little.

According to H. M. Eakin, placer mining in the Ruby district, as a whole, has shown considerable advancement over the previous year in spite of certain unfavorable circumstances. The distribution of profitable placers has proved more irregular than was expected, so that after working out limited areas many plants have had to take up prospecting for new deposits rich enough to be worked instead of continuing actual mining. The season of 1913 was exceptionally dry, so that only the plants equipped with pumping apparatus could work at full capacity. All told, there were 41 plants engaged in actual mining in the Ruby district, operating 38 claims on 14 different creeks and employing a total of about 230 men. There were also a number of prospecting outfits working on these and neighboring creeks. Of the 41 plants, 33 are equipped with steam machinery, aggregating over 750 h.p. The other 8 plants use manual methods.

Lode Mining.—In the interior of Alaska the principal lode mining was done at the quartz claims at Fairbanks. There are 14 stamp-mills in the district, including the new one of the Fish creek claims, as follows:

The annual meeting of the Newsboy Mining Co. was held at Fairbanks on January 18, 1914. Leslie M. Drury, the manager, stated that there was enough $20 ore in sight to last 3 months. Some of it being mined was worth $150 per ton. Work continues at the 100 and 300-ft. levels.

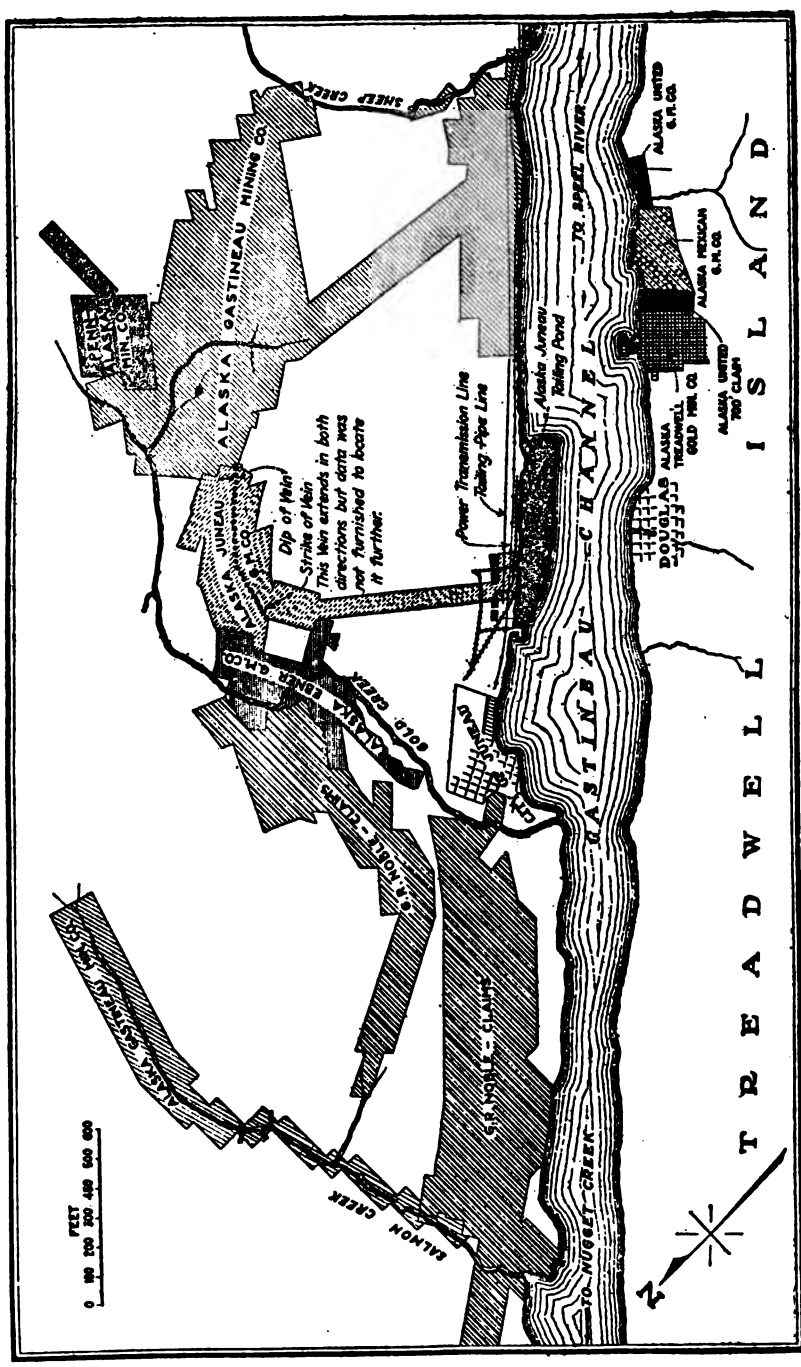


Fig. 1.—The mines and properties around Juneau, Alaska.

Mining cost $5 and milling about $2.50 per ton. Wood at $14.50 per cord makes the milling expensive, two cords per day being consumed. He proposed to install a 30-h.p. gasoline engine for $1500, and so reduce costs by 75 per cent. Revenue from gold was $36,979, and other receipts $15,368. The surplus is $18,864.

The total ouput of the quartz mines to date is about $1,000,000, of which the Rhoads-Hall produced $400,000.

Juneau, Alaska.—Regarding lode mining in other parts of the country interest centered around Juneau, where is the Treadwell group, and those being developed by the Alaska Gold Mines, which controls the operating company, the Alaska Gastineau Mining Co., also the Alaska Juneau Mining Co. Juneau will be one of the world's great centers for the milling of low-grade ores within the next year or two. The accompanying cut shows the location of the principal mines in this area.

Preparatory work of the Alaska Gold Mines Co., controlling the Perseverance and Sheep creek mines, near Juneau, was described by Grant H. Tod.[1] The ground being developed comprises a mineral district from 70 to 400 ft. wide, with an approximate length of 3 miles. The ore in this zone averages from $1.50 to $2 per ton, with an estimated recovery of from $1.25 to $1.50 per ton. The margin of profit is estimated to be from 50 to 75 cents per ton milled. The first unit of the plant will have a daily capacity of 6000 tons.

F. W. Bradley[2] writes on the Plans of the Alaska Juneau Mining Co., which has the Alaska Juneau, northwest of the Alaska Gold Mines property. The Juneau mine contains enough $1.45 ore for a daily output of 6000 tons, and a little lower grade for 20,000 tons within the next 4 years. The total cost will be under 80 cents per ton.

The Treadwell group on Douglas Island had the following output from the treatment of crushing with 900 stamps, amalgamation, concentration on Frue vanners, and cyanidation of the concentrate:

	Alaska Mexican.	Alaska Treadwell.	Alaska United.
Tons	227,112	886,057	448,427
Bullion	$489,697	$2,358,422	$1,043,543
Profit	171,797	1,223,437	385,065
Dividends	180,000	1,000,000	414,460

The Alaska United includes the results from the Ready Bullion and 700-ft. claims, their respective yields being almost the same.

In the other districts at Berners Bay, development work was continued on both the Jualin and Kensington mines. In the Sitka district the Chicago and Golden Gate were operated. In the Ketchikan district, the Jumbo and Rush & Brown copper mines shipped and development work was done by the Northland Development Co. The small stamp-

[1] *Min. Sci. Pr.*, CVII, 184.
[2] *Min. Sci. Pr.*, CVII, 881.

mills at the Valparaiso and Harris River gold mines were operated and some development done on the Londevan and Bugge properties. The two small mills of the Kenai Alaska Gold Co. and the Skeena-Lechner were operated part of the year, and underground developments continued. A 5-stamp mill was erected by the Gold Stamp Mining Co. and a small prospecting mill was built by the Moose Pass Mining Co. About 15 placer mines were operated on the Kenai peninsula in 1913.

During the summer considerable local excitement was caused by the discovery of auriferous gravels in the region adjacent to the upper Matanuska basin and 75 to 100 prospectors were attracted to this region. In May, W. E. James and P. Nelson found gold placers on the Little Eldorado, which eventually flows into the Chisana river. A rush set in, and at present there are about 400 to 500 men on the ground. There are many routes to the area, it being 260 miles from Dawson and 90 from Kennicott, on the Copper River railway. A good deal of litigation arose over the various claims, and decisions were given on some in March of the current year. A small rush set in for the Nelchina district, about 110 miles from Knik.

Arizona.—According to the inspector of mines for the state, G. H. Bolin, mining was never more active than at present. Primarily, Arizona is a copper producer, yet there are several important gold mines, and a good deal of prospecting is being done.

The Kingman district prospered in 1913, improvements being made at the three leading gold producers, the Tom Reed Gold Mines Co., the Gold Road Mines Co., and the Frisco Gold Mines Co. At the mills of the first two companies, changes were made introducing continuous decantation in place of vacuum filtration. The Gold Road mine yielded 103,628 tons of about $8 ore. The Frisco Co. installed two Kelly filters and otherwise increased its milling capacity. The Tom Reed's output in 1913 was $1,300,000, and about $800,000 was paid in dividends.

In Maricopa County, the famous old Vulture mine, reopened about 5 years ago by the Vulture Mines Co., operated steadily in 1913. The ore production for the year amounted to approximately 33,000 tons, the average value of which was about $20, and the yield approximately $17.40 per ton. About 5000 ft. of development work was done in 1913, and a winze is now being sunk below the 1050-ft. level.

The Commonwealth mine, at Pearce, Cochise County, has been operating its new 350-ton mill since about October, 1913. In February it was treating from 275 to 300 tons per day, and improvements are contemplated to increase the capacity and improve the results at present being obtained. The present development is entirely in the oxidized zone, and the indications are that the sulphides will not be found until great depth is

attained. Developments covered 6773 ft. during the past company year, and the ore reserves averaging $5.35 per ton, are worth $1,378,000 down to No. 7 level.

A good deal of the gold and silver output of this state is recovered as a by-product from copper smelting operations. For instance, the Copper Queen ores yielded 14,443 oz. gold and 680,939 oz. silver from 714,444 tons; Calumet & Arizona 18,989 oz. gold and 880,915 oz. silver from about 510,000 tons of ore; Old Dominion, 4254 oz. gold and 193,845 oz. silver from 337,878 tons; and Shannon, 3412 oz. gold and 169,197 oz. silver from 361,084 tons of copper ore. Others include the Arizona Copper, United Verde, and Shattuck, Arizona.

California.—According to preliminary figures compiled by Charles G. Yale, of the U. S. Geological Survey, the mine figures for 1912 were $19,713,478 in gold and 1,300,136 oz. of silver; the estimates for 1913 indicate an output of gold valued at $20,013,374 and 1,606,261 oz. of silver, an increase for 1913 of $299,896 in gold and 306,125 oz. of silver. There are about 1100 producing metal mines in the state, and the deep mines are yielding about 2,700,000 tons of ore annually It is probable that the increase in gold has come mainly from the deep mines, while the added quantity of silver has come from increased output of copper and lead-silver ores.

The producing deep gold mines of the state, which yield about 56 per cent. of the total gold output each year, are between 450 and 500 in number and are situated in 26 counties. They have nearly 200 reduction plants, with a daily capacity of over 12,000 tons. The largest production from this source is derived from the five Mother Lode counties, where about 1,300,000 tons of ore are annually treated with an average recovery of $3.70 per ton. During the year 1913 several of the old mines along the foothills and in the mountain counties have been reopened and equipped after lying idle for years, and some new "prospects" have been opened.

In placer mining in California the dredges continue to furnish about 86 per cent. of the gold derived from the auriferous gravels. Of the total gold yield from all sources, deep and placer mines, the dredges produce about 38 per cent. As yet there are no special signs to indicate any diminution of the total yield of gold from dredging operations, but some of the older fields are on the decline, the best ground having been worked out. A few of the companies have entirely worked out the paying ground in their holdings and have ceased operations. Hydraulic mines produce 8 per cent. of the placer gold output.

There has been notable advancement in the Mother Lode region, particularly in Amador County, according to Lewis H. Eddy, in the

Engineering and Mining Journal. All the large producing mines, with the exception of the Zeila, have been sunk farther and new ore-bodies disclosed. At the Kennedy a vertical shaft was deepened to 3850 ft., and two levels were opened below the 3450- ft. level, one at 3600 ft. and one at 3750. A fine body of ore was cut on the 3600-ft. level. The Argonaut opened new ore in the 3950-ft. level. The Oneida, which was taken over by the South Eureka in 1912, has been connected by drift with the South Eureka and large ore-bodies proved. Twenty stamps of the old Oneida mill were put in commission, making a total of 100 stamps in operation by the South Eureka Mining Co. The Central Eureka, Bunker Hill, and Fremont were also deepened and new ore found. The Hardenberg installed a 20-stamp mill. New steel head-frames were installed at the Bunker Hill and Fremont mines. The South Eureka installed a plant for the disposal of tailing from the stamp mills, and the Kennedy plant is now in operation, and was described in a May issue of the *Mining and Scientific Press* by M. W. von Bernewitz. The Argonaut is preparing to erect a new mill. Development at the Plymouth Consolidated and Keystone progressed satisfactorily. A 20-stamp mill is being erected for the former at Plymouth. Ore has been opened to 2000 ft., and reserves are 110,000 tons worth £150,667, with a profit of £72,858. The West Eureka was reopened at the close of the year, new ore-bodies disclosed. The East Eureka closed down the mine and 20-stamp mill in the first half of the year. The apex suit of the Kennedy Extension Gold Mining Co. *vs.* the Argonaut Mining Co. went to trial on September 15, 1913, and the taking of evidence was concluded on November 6.

Eldorado County advanced in the development and operating of a number of the mines. The most interesting item of development was at the Pacific mine at Pacerville in the deepening of the shaft to 2000 ft.

In Calaveras County, the Melones, the Utica, and the Gold Cliff were the only steady producers among the large mines. The Lightner was interrupted by the failure of the prospective producers to take the mine over and the original owners resumed operation The 40-stamp mill of the Dolling mine was closed down most of the year.

In Inyo County the Skidoo water pipe line, damaged by cold weather early in the year, was repaired; and the 150-ton stamp mill destroyed by fire was replaced by a new 10-stamp mill. The Wilshire Bishop Creek Co. erected a new 20-stamp mill driven by electric power, and a cyanide plant was ordered. The property was idle during the latter part of the year.

In Nevada County high-grade ore was opened at 2400 ft. in the Champion mine owned by the North Star Mines Co. Development in this group covered 9000 ft. The Golden Center at Grass Valley erected

a 10-stamp mill. The Tightner continued to produce rich ore, and a dividend of $500 per share was declared among a few shareholders. Another 10-stamp of new design was erected.

The report of the Brunswick Consolidated Mining Co. for 1913 showed that there is no large tonnage of ore developed, but the management from past experience estimate at least 15,000 tons of profitable ore available. A new vertical shaft was sunk to 400 ft., while a raise was driven from the 1250-ft. level to connect, this being finished in February, 1913. The stamp mill treated 15,334 tons of ore yielding gold worth $193,314, while the concentrate was worth $10,751 net. The year's profit was $60,675. A dividend of $23,717 was paid.

The North Star Mines Co. operates several properties and plants at Grass Valley, and the report for the year ended December 31, 1913, shows that the North Star and Champion mines produced 132,940 tons of ore yielding gold worth $1,324,275. Ore from the former mine came from above the 3400, 3700, and 4000-ft. levels. Development consisted in extending the 5000 and 5300-ft. drifts, and connecting various levels by raises. As a result, several years' ore supply has been opened on and above the 5300-ft. level. The main incline shaft is 5850 ft. deep, equal to 3200 ft. vertical. Dividends amounting to $300,000 were paid. Cash, investments, etc., at the end of the year, were worth $915,480. Costs were $5.203 per ton.

In Tuolumne County deep mining advanced during the year. The Dutch and the Harvard mines were deepened, new ore-bodies opened up and the mills were kept in steady operation. The Jumper, an old mine that is being reopened, was reported to have found some new ore of good value and the prospect was good for continuing the operation and reëstablishment of the permanency of the mine. The App mine is still idle, but the prospect of a sale was renewed in the latter part of the year. The Black Oak mine on the east belt had a good year, the new cyanide plant proving entirely satisfactory. The Eagle-Shawmut was operated satisfactorily with the exception of the time annually occupied in overhauling and planning for the succeeding year.

Near Columbia the Springfield Tunnel & Development Co. is driving an 8 by 8-ft. adit to drain its workings and some adjacent properties.

The output of gold from dredges in California in 1913 was about $7,250,000 from 70,000,000 cu. yd. handled by 56 boats. There are 20 in Butte County handling 17,000,000; 13 in Yuba County, handling 20,000,000; 11 in Sacramento County, handling 26,000,000; 3 in Calaveras County, handling 3,500,000; and 10 in Shasta, Placer, Trinity, Siskiyou, and Merced Counties treating 3,500,000 cu. yd. per annum.

The dredging areas of the state are decreasing rapidly, especially at

Oroville, where there are now only 13 dredges working against nearly 30 a few years ago.

During the 6 months ended July 31, 1913, the Oroville Dredging Co., with three boats, handled 1,612,519 cu. yd. of gravel, yielding 7.41 to 10.88 cents per yard. The total value was $173,458. Costs were 6.78 cents per yard dredged.

The Oro Water, Light & Power Co., operated one boat on the Mokelumne river, Calaveras County and four at Oroville, on the Feather river, during the year; and the Natomas Consolidated operated 10 boats at Natoma on the American river, and three at Oroville on the Feather river, yelding $542,240, and $2,299,261, respectively.

Over $300,000,000 in gold has been recovered from the old river channels, of the Tertiary period, in California, and they appear to be receiving a little more attention of late, especially in Butte County. Work is being done at the Nugget, Royal, Double Eagle, Robbers Roost, Smith, Emma, Conger, and Mineral Slide drift-gravel mines. The Indian Springs and Magalia mines will probably be reopened.

The San Francisco mint in 1913 received a total of 2,375,651.75 oz. of gold, from all sources valued at $49,109,079.18, as against 2,522,544.75 oz., worth $52,145,627.10, in 1912.

Colorado.—There were comparatively few new developments of importance in the state in 1913, according to George E. Collins in the *Engineering and Mining Journal.* Generally speaking, it may be said that the feeling of depression that has existed for several years, since the opening of Telluride and Cripple Creek, was continued and somewhat intensified. Ore is being mined faster than it is being developed, and the production, while large, does not yield profit in proportion to the difficulties encountered, and the risk. Cripple Creek and Telluride were the most prosperous districts. At the former place the Golden Cycle and Portland mills handled the larger portion of the output; Stratton's and the Ajax leading the smaller plants. A new mill is being erected at the Vindicator and El Oro. At Telluride the Tomboy, Liberty Bell, and Smuggler-Union maintained a large output, the Tomboy treating 11,000 tons per month for $75,000 with $30,000 profit. The Humboldt is being developed, and a new mill is about completed at the Junta Consolidated. Silverton is dull. The Buffalo Boy, believed to contain a large tonnage of cyaniding ore opened, is the subject of litigation. At Ouray, the Camp Bird is reducing its output. The last quarter of 1913 showing 1265 ft. of development, 77,820 cu. ft. of stoping, 14,663 tons of ore in stopes, bullion worth $193,918 from 8683 tons, with a profit of $89,405. The Atlas is about the largest producer there. Suspension

of work at the Topeka and Frontenac in Gilpin County, leaves a smaller output and reduced activity.

The San Juan region of Dolores, La Plata, Ouray, San Juan, and San Minguel Counties produced in 1913 $4,116,000 in gold, and 2,847,000 oz. of silver, compared with $4,115,345 in gold, and 2,562,095 oz. of silver in 1912, according to the U. S. Geological Survey. The yield of gold bullion in Boulder county decreased one-half.

Mineral production of Ouray county in 1913 was valued at $1,558,825, made up by crude ore and concentrates, $1,088,950; bullion, $459,875; and coal, $10,000. Thirty-two properties contributed to the output. The local smelter received 4000 tons of mine and mill products.

The American Smelting and Refining Co. reports the following yield from San Juan County ores smelted at its works: gold $413,096; silver, $493,796; besides lead and copper.

Leadville mines produced 453,360 tons of mixed ores, which yielded with other metals, 49,261 oz. gold and 3,315,270 oz. silver.

The gold production of Cripple Creek during 1913 was valued at $14,435,520, against $14,006,741 in 1912, making a grand total of $324,786,741, according to *The Cripple Creek Times*. At the local mills, at Colorado City, and the smelters, a total of 966,906 tons of ore was treated. The treatment of low-grade ore at the local plants is of interest as shown by the following table:

Plant.	Tons.	Average value.	Gross value.
Portland, Battle mountain	179,918	$2.97	$532,866
Stratton's Independence, Battle mountain	131,026	2.67	349,887
Colburn-Ajax, Battle mountain	54,994	3.27	179,905
Gaylord-Dante, Bull hill	17,700	2.95	52,315
Wild Horse, Bull hill	13,865	3.38	46,910
Kavanagh-Jo Dandy, Raven hill	19,315	2.10	40,600
Isabella mines, Bull hill	9,290	2.13	20,760
Rex M. & M. Co., Ironclad hill	2,700	1.68	4,400
Total	428,808	$2.86	$1,227,643

Dividends during 1913 were as follows: Golden Cycle Mining Co., $405,000; Cresson Con. G. M. & M. Co., estimated, $300,000; Portland Gold Mining Co., $300,000; Elkton Consolidated Mining & Milling Co., $200,000; Vindicator Consolidated Gold Mining Co., $180,000; Stratton's Independence, Ltd., estimated, $120,000; Strong Gold Mining Co., estimated, $150,000; Mary McKinney Mining Co., $104,740; El Paso Con. Gold Mining Co., $61,280; Stratton's C. C. M. & D. Co., $60,000; and Gold King Mining Co., $10,000; a total of $1,891,020. The profits of leasing companies and lessees is estimated at $350,000, making a grand total of $2,241,020. Dividends prior to 1913 were $38,128,584, and the total to 1914, $42,260,624.

Development in the Portland mine covered 12,433 ft. Results at No. 1 shaft, at 400 ft., were good; but at No. 2, save at 1600 ft., they

were unsatisfactory. Ore reserves keep to the usual tonnage. The Victor mill treated 178,163 tons for $402,923, and the Colorado Springs plant 53,245 for $1,380,713. The year's profit was $604,443, and dividends were $300,000.

The Isabella Mines Co.'s property, worked by 31 sets of lessees, produced 18,288 tons of ore worth $243,252 in 1913. The company's profit was $7129.

The annual report of Stratton's Independence, Ltd., contains the following: Ore treated, 130,110 tons; gold output, $302,000; profit, $115,000; ore sales on company account, profit, $67,000; ore sales on lessees' account, profit, $53,000; and dividends, $120,000. Mine development opened no new ore-shoots, and lessees' production declined, and is likely to decrease. A working profit of $7000 per month is all that is figured on for the future.

The annual report of the El Paso Gold Mining Co. for 1913, shows that development covered 4291 ft. The main shaft is down to the 1332-ft. of Roosevelt tunnel level. Ore from the Nichols shaft was of poor grade, and 60 per cent. was sorted out to make it of commercial value, $15.26 gross per ton. Lessees did 912 ft. of work above No. 4 level. Ore broken on company account in stopes is 42,240 tons. The year's operating profits were $69,927. Dividends were $110,250.

The Vindicator Consolidated company produced, on company and lessees' account, 33,517 tons worth $723,727. Lessees were paid $110,-577, and dividends were $180,000. Cash on hand at the end of 1913 was $227,112.

Although containing good veins and large tonnage of ore, the mining district of Rollinsville, Gilpin County, is very quiet, owing to the waiting game being played by claimholders. The Smuggler has a 10-stamp mill, with amalgamation and concentration.

In the fall of 1912, silver ore was found in the Brush Creek district of Eagle County, and a rush set in in February, 1913. The ore is in a sandstone. The Lady Belle has been shipping ore regularly since. The North Dakota is also shipping, and about a dozen other claims are promising.

The Tonopah Mining Co. of Nevada has acquired a large area of dredging ground and some dredges in the Breckenridge district, and under the name of the Tonopah Placers Co. has started active work.

Idaho.—The gold and silver output of this state in 1913 was $1,450,-531 and 10,163,205 fine ounces, against $1,432,434 and 8,238,971 fine ounces, respectively, in 1912, according to the state inspector of mines, Robert M. Bell in his annual report. A great deal of both metals is from the treatment of copper, lead, and zinc ores. In the first group

are the Empire, Lost Packer, Snowstorm, and National. At the latter a 500-ton mill is now working. Shipments of lead ore and concentrate containing silver were unusually large. The lead mines yielding silver are the Bunker Hill & Sullivan, Federal group, Stewart, and Ontario. Lead-silver ore development outside of the Coeur d'Alene district received considerable attention. In Blaine County, the Wilbert mine opened high-grade lead, but low silver ore; in Lemhi County ore shipments from Gilmore totaled 22,000 tons of 30 per cent. lead, 15 oz. silver, and a little gold ore; 100,000 tons of lead-silver ore were opened in the Red Bird mine in Custer County.

The falling off in the gold production was partly due to closing down the Delamar mine in Owyhee County, a steady producer for 20 years, and a total yield of over $10,000,000. The Boston & Idaho Gold Dredging Co., at Idaho City, has been the principal placer producer. The two boats are handling from 12,000 to 14,000 cu. yd. of gravel per day worth from 10 to 20 cents per yard. The gold output from dredging continued to increase. In Lemhi County, the Kirtly Creek Gold Mining Co. operated its plant throughout the year. Very rich gold ore was recently opened in the Allie mine at Gilmore, and shipments in car-load lots to Salt Lake City have been worth over $350 per ton. In the Big Creek district, Idaho County, there are several sheared deposits of quartz and altered granite gangue carrying iron sulphides and $2 to $4 per ton in old, and from 100 to 300 ft. wide, which may be worked profitably on a large scale at some future date.

Shipments of lead-silver-zinc ores and concentrates from mines in the Coeur d'Alenes, average about 40,000 tons per month. The properties contributing to this total are as follows: Bunker Hill & Sullivan (2,604,119 oz. silver in ore produced during the 19 months ended December 31, 1912) Federal, Stewart, Hercules, Green Hill-Cleveland, Hecla, Custer Consolidated, Success, Sierra Nevada, Gold Hunter, Ontario, Marsh and Yankee Boy, the last being a silver mine.

The report of the Federal Mining & Smelting Co., for the year ended August 31, 1913, shows the following: ore milled, 637,900 tons; concentrate produced, 84,533 tons; silver content of concentrate, 15.9 oz. per ton; or say about 1,350,000 oz. Dividends were $719,166, gross earnings being $3,553,325. The surplus is $1,438,308. The Stewart Mining Co. is earning up to $340,000 per quarter, and making a profit of $190,000. Monthly dividends from the Bunker Hill & Sullivan Co. are continued at $81,750, the total to the end of March, 1914, being $15,056,000.

Montana.—The important gold-producing counties of this state are Madison, Silverbow, Broadwater, Fergus, Blaine and Lewis and Clark.

The source of the gold varies widely. In Madison County the four dredges of the Conrey Mining Co. are the chief producers. In Silverbow County the gold is a by-product of the copper ore, and does not amount to much. It takes 5,000,000 tons of ore from the Anaconda group of mines to yield 30,000 oz. of gold, which means about 12 cents per ton. The milling ores are found in Fergus and Blaine Counties, both of which contain several cyanide plants. In the former county, the Barnes King Development Co. has had the most successful year of its existence. It bought the North Moccasin mine and paid for it out of profits from the mine. The gross earnings were $414,594, and net profit, $129,906. The treatment plant is now handling up to 4300 tons of ore per month at a cost of about $4.75 per ton. The Magpie Placer Mining Co. operated a dredge on Lake Sewall, 20 miles northeast of Helena, handling about 70,000 cu. yd. of gravel monthly. The St. Louis Mining & Milling Co. operated the St. Louis and Drumlummon mines at Marysville, reconstructed the stamp mill, and installed a new cyanide plant, but later was forced to suspend operations.

At the Easton-Pacific mine owned by the Ellings, of Virginia City, a new cyanide plant was constructed and operated steadily on the ore mined there. The Missouri mine on North Meadow creek was also operated by the Ellings.

Many other counties of the state yield various amounts of gold, but are not comparable in importance with those above mentioned.

A Californian dredging company has acquired an option on about 200,000 acres of land near Twin Bridges, in Madison County, and if drilling proves profitable ground, considerable dredging will be done. For agricultural purposes, the land is worth under $25 per acre, but the option calls for $100 per acre.

Silverbow County so far excels all other counties of the state in silver production that the others need hardly be mentioned. It produced about 11,000,000 oz., while the state totaled 13,819,201 oz. The silver from Butte, in Silverbow County, is chiefly a by-product of the copper ore, averaging about 2 oz. per ton of ore mined, and some from the zinc ore of the Butte & Superior mine. Jefferson and Granite Counties are the others which each produce several hundred thousand ounces of silver. The ore is mostly shipped to smelters for treatment, and is not milled.

Nevada.—This is an important gold and silver-producing state, most of the precious metals being the result of direct treatment, that from smelting being comparatively small. There appeared to have been a good deal of active prospecting, and several rushes set in to widely separated districts. The new 350-ton mill and cyanide plant for the Buckhorn

Mines Co. started at the end of the year. A 500-ton plant is under construction for the Aurora Consolidated Mines Co., in Mineral County. Both of these mines are low grade, being about $5 per ton. The Pittsburg-Silver Peak, Nevada Hills, and Round Mountain mines continued to yield their regular tonnage. In the latter there have been good developments. At Manhattan a number of mines, three mills, and placers were worked. The Big Four mill was stopped on account of the low value of the ore. The field is generally low grade, and there will probably be a consolidation of interests and working on a larger scale. In Lincoln County a number of properties were busy. At Rawhide there are three mills at work, but little is heard of that once famous district now, save that genuine work is being accomplished. There was more activity at Goldfield than for years past. The Goldfield Consolidated Mines Co., in 1913, produced 349,465 tons of ore, 330,217 tons averaging $14.28 were milled and 19,248 tons averaging $27.39 were shipped. The latter contains copper and gold. The gross value of all ore was $5,438,853. The bullion realized was $4,942,828. Mining, transport, milling, construction, taxation, and general expenses were $2,210,883, or $6.38 per ton, leaving a profit of $2,731,945. Dividends totaled $2,491,403, and $26,330,471 to date. Cash balances total $1,074,372. To date the output is $59,475,201. Development covered 38,696 ft. in 1913, at a cost of $8.42 per foot. Measurable ore-bodies contain 136,000 tons of average grade. This estimate shows larger quantities than at the beginning of the year. This estimate shows larger quantities than at the beginning of the year. A large tonnage of low-grade ore remains in the mine.

The Jumbo Extension Mining Co. mined 9701 tons, of which 9166 tons were concentrated, yielding 709 tons of concentrate, while 533 tons was sent to smelters. The total yield was 3382 oz. gold and 11,336 oz. silver worth $74,358, and 115,521 lb. of copper which realized $16,751.

The companies at Rochester, Humboldt County, are doing a good deal of work, and although handicapped by litigation, poor transport, and the want of a local treatment plant, the silver-gold ore output is increasing. A number of properties will probably be consolidated. The Rochester Hills Mining Co. constructed a narrow-gage railway 4 1/2, and a wagon-road 9 miles long to the Southern Pacific line. This helped the district considerably, and is being extended to the mines. This Company's property is fairly well equipped and reserves opened by an adit and shaft 165 ft. below it total 25,000 tons of $12 to $16 ore. During 1913, 9167 tons were shipped to smelters worth $175,762. The net return was $62,613. Cash on hand is $6018. The Rochester Mines Co.'s mine was opened by the Company and lessees. Development covered 13,922 ft. Ore shipped totaled 14,726 tons worth $368,770.

Costs were $25.04, of which lessees got $9.79 per ton. The net profit, $19,192. The Rochester Weaver Mining Co. let most of its mine to lessees, who shipped 953 tons worth $30,254, from which the Company drew $2783 in royalties. Ore has been proved to 350-ft. depth, and leasing is to be abandoned, although it has opened the property cheaper than on company account. Three veins, 5 ft. wide, worth $8.50 per ton, are to be developed. A number of smaller claims are being actively prospected.

For the year ended September 30, 1913, the Comstock district produced bullion worth $1,245,530, according to the state controller. During 1913, the Crown Point produced 6678; Belcher, 2924; and Yellow Jacket, 14,341 tons of ore, which was treated at the Jacket mill, yielding 3319 oz. gold and 29,049 oz. silver. A good deal of time was spent in installing centrifugal pumps in the joint Crown Point-Belcher incline.

The report of the Mexican Gold & Silver Mining Co., for the year ended October 31, 1913, shows that the 2400- and 2500-ft. levels were practically exhausted of ore, and with the 2300-ft. level yielded 14,172 tons averaging $28.65 per ton. Owing to a dispute with the pumping company, work was transferred to the Monte Cristo mine. The Mexican mill treated a total of 29,365 tons yielding 17,870 oz. gold and 322,758 oz. silver worth $564,258. Including cash, $253,922, the balance at the end of the financial year was $313,851.

The Ophir cyanide plant, treating old and current tailing, was operated during the year at a good profit.

One of the most important events of the Comstock was the unwatering of the 2700-ft. level by the United Comstock Pumping Association. With its series of pumps at different levels, this was done early in 1914, the bottom level being dry for the first time in 30 years.

The passing of the Comstock Lode was described in a series of articles by W. H. Storms,[1] starting with the work of 62 years ago to the present time. This included early prospecting, active mining, timbering, treatment processes, lawsuits, labor troubles, bonanzas, water in the mines, and work up to the present time.

Tonopah was the scene of considerable development and increased output, in spite of interruptions to power, floods, and stock manipulations in some of the smaller mines. According to Frederick Bradshaw, of the Belmont mine, the district produced about 120,189 oz. gold and 11,973,540 oz. silver from 551,710 tons of ore, and worth $9,721,727, against 112,642 oz., 11,027,736 oz., 474,521 tons, and $9,110,955 respectively in the previous year. Dividends totaled $3,353,482, against $3,331,550 in 1912. Details of the outputs were as follows:

[1] *Min. Eng. World*, XXXIX, 877.

PRODUCTION OF TONOPAH MINES IN 1913.

Mine.	Tons.	Silver, oz.	Gold, oz.	Value.	Dividends.
Belmont	168,062	4,167,070	42,999	$3,284,669	$1,650,000
Extension	54,618	.....	.....	750,749	.....
Jim Butler	20,164	512,081	5,383	238,355	111,397[1]
MacNamara	28,098	266,772	2,842	266,772	.....
Montana	52,402	784,494	8,978	665,208	100,000
Tonopah mining	168,283	3,579,370	.....	2,135,364	1,450,000
West end	50,175	.....	.....	920,741	.....
Halifax, North Star, Midway	10,993	.....	.....	339,715	.....

[1] Profit.

The Tonopah Belmont has opened its Shaft vein to No. 13 level, showing good ore. The Middle vein was cut at No. 12 level. A considerable amount of work is in progress from the Desert Queen shaft in the western part of the property. The West End has retimbered its main shaft, erected an electric hoist, and is sinking the main shaft to 1000 ft. Ten stamps and a tube-mill are being installed. Litigation has started between this company and the Jim Butler over ore in the latter's Eureka claim. The Jim Butler is producing and prospecting to 800 ft. The Merger is down to 1170 ft. Extension's Murray vein is opening well from 950 ft. In the Montana, the MacDonald vein from 698 to 765 ft. will yield a large tonnage of good-grade ore. The Tonopah has covered the usual work in the Red Plume, Silver Top, and Sand Grass mines. Other work was done at MacNamara, North Star, Halifax, Midway, Cash Boy, and Buckeye-Belmont.

Manhattan produced 54,260 tons of ore worth $442,262, according to the Chamber of Mines. Of this the Associated yielded 3082 tons for $52,209; Manhattan, 13,647 tons for $130,386; Big Four, 18,294 tons for $79,668; East Side, 103 tons for $1770; War Eagle (estimated), 18,442 tons for $140,000; and shipped by White Caps Co., 692 tons for $38,229.

New Mexico.—The most important producing center of this state is in the Mogollon district, Socorro County. The ores yield silver and gold, and the area is being actively developed and produces a good deal each year. The Socorro Mining & Milling Co. ships about 2 tons of gold-silver bullion, and a good tonnage of high-grade concentrate monthly. A shoot of ore 10 to 15 ft. wide, worth $60 to $135 has been opened in the Pacific. The Oaks Co. is driving a main drainage and transportation tunnel for the district, which will eventually be under the large mines of the district at depths from 1400 to 1800 ft. The Deadwood mine was worked full time. The Lordsburg district, in Grant County, is attracting some attention of late. Several mines are producing gold ore. Other gold and silver produced in the state is as a by-product from copper and zinc ores.

Oregon.—This state has not attracted much attention, yet steady

development has been done in deep mines and placer properties, and the gold and silver output is increasing. During 1913, the production of gold, silver, lead, and copper was about $1,925,000, according to the Oregon Bureau of Mines and Geology. Of this amount, $225,000 in gold and silver came from the Counties of Josephine, Jackson, Lane, Douglas, Curry, and Coos in southern Oregon. The ratio between the placer and deep mining yield was over two to one. In eastern Oregon, the 1913 yield of gold and silver was $1,700,000 from Baker, Malheur, Grant, Wheeler and Crook Counties. Of this, 75 per cent. came from deep mines. These are of two classes, those which concentrate and ship their product to smelters, and those which amalgamate and cyanide their ores. The Ben Harrison, Humboldt, and Highland are in the first class, and the Cornucopia and Rainbow have modern treatment plants. The Powder River Dredging Co., operating near Sumpter, started a 9-ft. dredge in January, 1913, swelling the gold output of the state considerably.

South Dakota.—While the tonnage and bullion yield of the Black Hills showed a slight decrease from 1912, yet the past year was one of marked progress, according to Jesse Simmons in the *Engineering and Mining Journal.* The Homestake Mining Co.'s report for the full year shows the following results: Development covered 16,313 ft. of drifts and 686 ft. of raises. Broken ore in stopes amounts to 2,206,671 tons, an increase of 176,000 tons. Ore crushed by 1020 stamps was 1,540,961 tons, yielding gold worth $6,186,652, from the mills and cyanide plants, equal to $4.018 per ton. Dividends were $2,146,224, equivalent to $1.39 per ton. Mining costs were $1.48, milling, 25 cents, and treatment of sand and slime, 20 cents per ton. A good deal of work was done on surface equipment, and for the current year this is estimated at $350,000. A large recreation hall was erected for all employees. The Homestake is one of the world's greatest mines. Assets are worth $23,811,776.

The Golden Reward produced about $500,000, the mill at Deadwood working to full capacity. The Trojan continued prospecting and new equipment. The Deborah and Empire produced ore, and the mill is up to date. The Mogul mill is being erected to replace the one burned in 1911. At Flatiron, the Bismarck mill was started. It is of 300-ton daily capacity and is a model dry-crushing plant. The property adjoins the Wasp No. 2. Continuous decantation, with counter-current solution system and a Portland filter treated 75 tons daily at the New Reliance. A fine 10-stamp mill is being erected by the Rattlesnake Jack Mining Co. near Galena. The Lundberg, Dorr & Wilson mill, a pioneer in cyanide work, went out of business. The report of the Wasp No. 2 Mining Co. for 1913, operating at Flatiron, shows that 127,680 tons of ore was treated, yielding $219,335, or $1.718 per ton. Operating costs were $167,392, and

net profit $24,543. Dividends, equal to 11 per cent. on the capital, absorbed $55,000. The operating time was 8.3 months. The ore is mined by open-cuts, although it is covered with an overburden of 14 to 18 ft. of soil and shale. Total costs were $1.311 per ton, and recovery, 77.39 per cent. of the gold, and 39.48 per cent. of the silver.

Mine development at the Heidelberg group, Carbonate camp, Ironsides, and in Custer and Pennington Counties was encouraging.

Texas.—Estimates by the U. S. Geological Survey place the 1913 gold yield at $100, and 401,415 oz. silver. The greater part of the state's metal output comes from the Shafter district, Presidio County. Lead-silver ore was shipped from the Sierra Blanca district, El Paso County.

Utah.—This state is essentially a producer of copper, lead, and zinc, yet on the list of gold and silver-producing states it stands in seventh and third places respectively. The precious metals are mainly by-products of treating base-metal ores of Park City, Tintic and Beaver County mines, which shipped 81,822,370,240; and 81,641 tons of ore and concentrate respectively. There are three large smelting plants in the state reducing base-metal ores.

After being worked for about 25 years, doing considerable pioneer work in cyaniding and developing new apparatus, producing gold worth over $17,000,000, and paying $3,445,313 in dividends, the Consolidated Mercur closed down at the end of March, 1913, as results were not profitable. There was little direct production of gold from siliceous ores in the state.

Park City produces silver with its zinc and lead, and a good deal of metallurgical investigation is being done for its recovery, and the active mills of the camp at present are the Silver King Coalition, Daly-Judge, Mines Operating, and some small jigging plants along the stream running from the Daly-Judge mill. Others are proposed. The American Flag mine has 50,000 tons of $10 gold-silver ore, and tests have been made by chlorination, and concentration followed by cyanidation. Without going into detail in regard to the tests, it was found that concentration alone was unsatisfactory, and that a recovery of 36 per cent. of the silver, 49 per cent. of the gold, and practically all the lead was the best that could be expected. A combination of concentration and cyanidation gave a final extraction of 92 per cent. of the gold and 74 per cent. of the silver, consuming 3.4 lb. cyanide. Leaching with sulphuric acid before cyanidation also gave a fair recovery, with a reasonable cyanide consumption. Chlorination promises a recovery of 92 per cent. of all the metals at a lower cost than any of the other processes, and since this method of treatment is in practical operation, its adoption has been decided upon.

During 1913, the Daly-Judge produced 618 oz. gold and 611,378 oz.

silver, with lead, zinc, and copper, from 53,897 tons of ore. Dividends paid by the Silver King Consolidated totaled $308,791 in 1913.

The Iron Blossom at Tintic produced 7289 oz. gold and 1,355,392 oz. silver, besides lead and copper, from 39,526 tons of ore in 1913. Gold and silver in 51,173 tons of ore shipped by the Chief Consolidated in 1913, amounted to 4751 oz. and 1,017,107 oz. respectively. Dividends of $175,307 were paid. The Eagle & Blue Bell's yield was 7514 oz. gold and 417,279 oz. silver, with lead and copper. Net earnings were $147,198.

Washington.—The gold output of this state was $696,275, according to the U. S. Geological Survey. This was mostly from the Republic district, where litigation and power troubles have interfered with operations. The San Poil mill has been treating up to 3000 tons of ore per month, while several thousand tons from the Republic Mines Corporation, Ben Hur, Quilp, and others has been sent to smelters in British Columbia. About 78 per cent. of the gold output came from crude ore and concentrate shipped, largely the former, and about 22 per cent. from cyanide and amalgamation bullion. There has been a fair amount of activity in placer mining near Liberty, in Kititas County. The Republic Mines properties are now in the hands of a new company, and considerable development is to be done. Silver production was chiefly from Republic and Chewelah mines, the latter producing copper ores which are shipped to British Columbia. There was a decrease in silver yield of about 21 per cent. from 413,538 oz. in 1912 to about 331,239 oz. in 1913. The silver content of the latter ores decreased.

Gold and Silver Mining in Foreign Countries

Africa.—This continent, which contains the gold fields of the Transvaal, Rhodesia, West Africa, Egypt, German and Portuguese East Africa, and the Congo, contributed £42,000,000 toward the world's output in 1913, or approximately 46 per cent. During the current year this proportion will probably be increased to 50 per cent. The Transvaal yield will probably remain at about the present, Rhodesia will increase considerably on account of starting new mills, West Africa may increase slightly, while the other areas will return the usual output.

Central Africa.—The gold production increased satisfactorily in 1913, the output, if the state's forecast for the Kilo and Moto mines is correct, being about 1380 kg., valued at about $828,000, according to Sydney H. Ball and Millard K. Shaler in the *Mining and Scientific Press.* In midsummer there were widespread reports of sensational gold discoveries in the Belgian Congo. These appear to have been without foundation. Fair alluvial ground has been discovered during the year at several places in the Uelle and in the Katanga, and some gold quartz in the Kilo

region, but none of these are, as yet at least, known to be of much importance. Those at the head of Kibali river, southwest of Moto, appear most promising.

The four producing gold placers in the colony are situated in the northeastern part of the colony, a region of ancient rocks which have been deeply eroded. Beginning with January 1, 1914, the state will turn over to the Grand Lakes Railroad Co. the two larger placers of this region, Kilo and Moto. The profit beyond a certain amount, however, is to be divided between the colony and the railroad. In return for these and certain extensions to its prospecting rights, the company relinquishes about 8,000,000 hectares of forest land. The Kilo placer is worked by primitive sluicing methods, although there is also a giant at work. About 30 whites and 2600 blacks are employed. The natives are paid a minimum wage of 4 cents per day and are, in addition, given food, lodging, blankets, etc. The gold is said to cost about $347.40 per kilogram, and to be worth about $597 per kilogram (or $18 per ounce), silver being the chief impurity. About $7,250,000 of gold-bearing gravel is supposed to be blocked out. At Moto, where sluicing began in 1911, seven white men and 1350 natives are employed. Gravels containing gold valued at $500,000 have been proved to date.

In the Parliamentary discussions preceding the transfer of these placers from the colony to the Grand Lakes Railroad Co., the following figures were presented regarding the Kilo and Moto placers, under state régime: Cost of exploitation from 559,000 to 2,380,815 francs, and sale of gold, from 981,424 to 1,767,863 francs in 1908 to 1913, the product of Kilo and Moto being 1360 kg. in 1913. The Kamva placer, owned by a Belgian-American company, produced a little gold, and the Babeyru placer has just started production.

Egypt.—The principal gold producers in this country, or really the Sudan, are the Barramia and Sudan mines. Each has a 10-stamp mill, the latter having a cyanide plant.

The Barramia mine is characterized by the occurrence of small rich pockets of ore, one of 59 tons yielding 480 oz.; and another of 84 tons giving 1192 oz. But these were not so numerous as in 1912. Ore reserves are 16,500 tons averaging $10 per ton. The mine is down 503 ft. below the adit-level. In 1913, the mill treated 4300 tons yielding gold worth £17,823, a profit of £3326, after paying royalty and a dividend of £2542.

Ore reserves in the Sudan total 42,862 tons. About 1600 tons of high-grade ore was opened in a folded portion of the vein. During 1913 development totaled 5304 ft. The plant treated 17,049 tons of ore yielding £39,597, and a profit of £6068.

Portuguese East Africa.—The chief events of this country in 1913 was the progress made at the Braganca mine, owned by the Andrada Mines, Ltd., and the completion of a Bucyrus dredge of 7 1/2-cu. ft. capacity on the river Berne, for the same company. The mine has been developed to 410 ft. The output was 4891 fine ounces gold, of which 355 oz. was in concentrate. The boat will be driven by electricity. Two other small mines were operated. The total output of the territory was worth £23,955. The Geological Survey has investigations under way.

Rhodesia.—This colony's gold output is still increasing, that for 1913 being £2,903,267, an increase of £195,899 over 1912.

There have been no sensational discoveries made during the past 12 months. In addition to the knowledge of the various mineral belts of Matabeleland and Mashonaland, that is continually being added to by individual prospectors and small syndicates, the Geological Survey of Rhodesia has extended its sphere of investigation and has collected considerable valuable data.

The Eldorado Banket and Giant had reduced yields, the former treated 7533 tons for £18,762 in January, and 8004 tons for £12,636 in December, while the latter treated 11,000 for £13,717 in January and 11,000 for £9422 in December. The Globe & Phoenix is the leading producer, treating up to 6700 tons for £45,300 per month. Ore reserves total 184,000 tons averaging over 1 oz. per ton. The Rezende and Lonely Reef had profitable runs, yielding up to £11,400 and £21,000 per month respectively. During 1913, the latter produced £218,520 from 58,903 tons of ore, and £81,302 in dividends. The Wanderer is still treating its 12,000 tons ore worth about $2.64 per ton. New mines with large ore reserves are the Shamva, Cam & Motor, and Falcon. All are being equipped with mills, and the Cam & Motor is now at work, the first run being 10,693 tons averaging $7.58 per ton.

The silver output of the territory was about 130,000 oz.

West Africa.—In spite of many difficulties, such as climate, labor, transport, mining and metallurgical, this far off country is increasing its gold output, that of 1913 being £1,634,700, against £1,497,179 in 1912. The principal producers, with average monthly outputs, are the Abosso, 8600 tons, for gold worth £15,000 and a profit of £2000; Ashanti, 11,119 tons for £36,000; Broomassie, 2400 tons for £13,000 and £1000; Prestea Block A, 22,000 tons for £38,000; Tarquah, 5160 tons for £14,500 and £2800; and Abbantiakoon, 9500 tons for £18,000. The 1913 totals were, Abbantiakoon, 55,544 fine ounces; Abosso, 43,002 oz.; Ashanti, 106,377 oz.; Bibiani, £35,153; Broomassie, £134,813; Prestea Block A, £386,917; and Tarquah, 41,653 oz. Four dredges of the Offin River Co. recovered £24,072. During the year ended June 30, 1913, the Ashanti

Goldfields Corporation treated 148,447 tons of ore, yielding 107,977 oz. gold and 7296 oz. silver, realizing £476,800 including bullion from old tailing. The working profit was £253,116, and net £175,147. Dividends totaled £187,507, including part from the last balance. Costs were $9.40 per ton, $6.24 in West Africa. Ore reserves total about 290,000 tons.

Transvaal.—The gold yield of this British colony in 1913 provided approximately 40 per cent. of the world's total, and results may be summarized as follows, the Rand and "outside" districts included:[1]

	1913.	1912.
Mines operated	60	68
Labor employed at end of each year, white	21,327	24,334
Labor employed at end of each year, native	150,012	206,121
Ore hoisted, tons	28,702,081	29,163,803
Waste sorted out, per cent	10.74	12.57
Stamps working	9,912	10,027
Tube-mills working	287	270
Working time, days	312.60	325.07
Duty per stamp day, tons	8.71	8.29
Ore crushed, tons	26,267,840	26,071,841
Total yield, fine ounces	8,794,824	9,124,299
Working costs	£23,609,272	£24,313,622
Working profit	12,675,075	13,101,016
Dividends paid	8,585,432	8,291,477
Yield per ton milled, shillings	28.00	29.25
Working costs per ton, shillings	18.08	18.75
Working profit per ton, shillings	9.66	10.08
Silver output, ounces	882,871	1,018,253

The difference between working profit and dividends paid is a noticeable point, and during the past 3 years the profit distributed has only been 68, 64, and 65.7 per cent. respectively of the nominal profit.

Important events affecting the usual steady work of the Rand, and resulting in the first decline in the output since 1901, were the following: A serious and regular shortage of native labor, as shown by the above table; an ill-advised strike of white employees in July, during which month there was a decrease of 17,852 natives, and conditions at several mines were considerably disturbed (another strike of railway men in South Africa occurred early in 1914, but prompt action by the Union Government saved there being a shutdown at the mines); a decrease in the yield of gold per ton milled; decrease of gold content with depth; the closing down of the Jupiter and Cinderella Consolidated; and poor results at the Simmer Deep, these being deep mines, the first named being down to 5000 ft.

As regards the future of the Rand, the Chamber of Mines recently estimated the life at 28,000,000 tons per annum for 5 years more, and a decrease to one-half of the present tonnage by the year 1931. Previous estimates are as follows:

[1] Transvaal Chamber of Mines *Monthly Analysis.*

Estimated by	Year made	Life till
J. Hays Hammond	1901	1926
F. H. Hatch and T. H. Leggett	1902	1944
Loan estimate	1904	1934
F. H. Hatch	1911	1950
G. A. Troye	1913	1940
Chamber of Mines	1913	1940

In H. H. Webb's report to the Consolidated Gold Fields of South Africa, he stated that the average gold content of the ore developed has been decreasing as greater depth was attained. Probably every mine on the Rand has proved disappointing in this respect. Deep-level areas of the Simmer & Jack have produced small working profits on ore assaying less than £1 per ton.

Returns of some of the important producers in 1913 were as follows, the stamps and tube-mills being those at work in December:

Mine.	Stamps Working.	Tube-Mills.	Tons milled.	Yield.	Working Profit.	Dividend.
Brakpan	140	8	613,269	£864,600	£291,660	£243,750
City Deep	150	9	468,400	885,120	292,990	218,750
City and Suburban	150	2	307,475	583,528	246,437	204,000
Con. Langlaagte	80	8	523,100	711,363	252,232	95,000
Crown Mines	660	24	2,195,600	3,248,131	1,431,632	1,034,116
Durban Roodepoort Deep	100	3	291,590	420,512	62,246	22,000
East Rand Proprietary	820	25	1,739,000	2,772,754	983,014	611,474
Ferreira Deep	245	6	645,070	1,304,738	680,442	490,000
Geldenhuis Deep	300	7	623,300	907,604	145,534	102,507
Knight's Deep[1]	400	11	74,800	66,413	12,689	117,617
Modderfontein B	80	5	404,580	784,427	450,000	315,000
New Kleinfontein	200	4	530,600	733,997	240,451	72,750
New Modderfontein	180	7	521,650	1,039,604	528,645	420,000
Nourse Mines	260	7	585,286	886,702	244,499	234,549
Randfontein Central	875	27	2,533,043	3,103,166	921,134	419,370
Robinson	250	6	668,900	1,196,475	726,859	412,500
Robinson Deep[1]	105	8	49,000	74,042	28,004	275,000
Rose Deep	300	7	768,070	1,007,354	365,964	297,500
Simmer & Jack[1]	320	7	68,500	73,112	29,413	412,500
Simmer Deep[1]	180	9	57,150	44,831	669	.....
Van Ryn	140	6	438,760	609,919	269,445	237,500
Van Ryn Deep[1]	80	8	37,050	62,017	26,454	89,767
Village Deep	180	7	536,300	798,687	242,022	159,101
Village Main Reef	220	5	436,273	787,273	388,984	330,400
Witwatersrand	220	4	449,400	575,667	270,141	234,812
Witwatersrand Deep	245	4	518,230	750,613	303,228	192,500

[1] December yield, but divided for full year.

The nine properties in the Heidelberg, Barberton, Klerksdorp, and Lyndenburg districts crushed 51,031 tons with 552 stamps and 9 tube-mills, yielding £127,555, with a profit of £38,742.

ASIA.—Under this head are grouped China, Dutch East Indies, India, Japan, Korea, and the Philippine Islands. Siberia, although occupying such a great area, is included with Russia. Probably the most important single group of gold mines is at Kolar, State of Mysore, India. Japan has a number of good mines, and there are several in Korea.

China.—Gold is produced in many parts of China, but figures of annual yields are almost impossible to obtain. In the Hupeh and Hunan provinces, in central China, there are somewhat extensive placer deposits

along the rivers, but worked in a primitive manner. Returns vary from 1 to 4 cents per cubic yard in the former province. In Hunan a series of bench gravels have been worked in a fashion for centuries. Most of the ground is topographically suited for dredging, but the gravel is too thin and low grade. According to E. C. Thurston,[1] gold is widely distributed throughout China, but probably in no readily accessible district in sufficient quantity and sufficiently concentrated to warrant foreign exploitation.

The best-known gold mine in China is at Chou Yuen, in Shantung, where some years ago ore carrying about $10 was crushed by stamps, amalgamated, and the concentrate chlorinated.

The mineral wealth of Mongolia is at present practically undeveloped, but from a geological examination, and from reports from prospectors during the last few years, it appears to be of great value, especially in the north. An American company is working seven mines, according to an eastern contemporary.[2]

Dutch East Indies.—Details of operations in this territory are not obtainable until late in the year. The Redjang Lebong and Ketahoen, in Sumatra, worked steadily, although the silver and gold returns are decreasing. The returns of the former were 43,660 oz. gold and 232,894 oz. silver, worth £212,650, against 53,040 oz., 202,016 oz. and £251,330 in 1912, respectively. Dividends were 15 per cent. on the capital compared with 25 per cent. in 1912, 50 per cent. in 1911, and 90 per cent. in 1910. The Lebong Simau paid 20 per cent.

In Dutch Borneo there is a little dredging and quartz mining being done; and in Sarawak, the English area of that island, the Borneo Co.'s cyanide plants continued their interesting work.

In the Celebes gold and copper mining is prosecuted.

India.—As mentioned earlier in this section, the center of gold mining in this British possession is at Kolar. It is characteristics of the ore-bodies that they are narrower, and the gold content generally persists to great depths, work in the Champion Reef being done to 4289 ft. on the incline, and folding in places. All of the mines are well developed, and contain large reserves. Practically the only backward development in recent years was at the Champion Reef, which passed through a poor zone of ore. Some of the mines make a good deal of water. Air-blasts are still troublesome in injuring employèes and timbers; in fact, in one part of the Champion Reef, work had to be suspended on this account. The equipment on the mines is kept in good order. New slime-plants have been installed at several mills. The Mysore Government supplies electric power at reasonable rates from its Cauvery River hydro-electric plant.

[1] *Min. and Sci. Press*, CVI, 272.
[2] *Far Eastern Review.*

Generally speaking, the Kolar group of mines is extremely well managed and profitable. The Indian gold output is increasing slowly each year.

INDIAN MINES OUTPUT IN 1913.

	Tons.	Gold Yield.	Profit.	Dividends.
Balaghat	42,700	£66,000	£2,348	.....
Champion Reef	220,511	510,737	195,273	£130,000
Mysore	302,662	905,090	490,269	381,250
Nundydroog	90,650	304,326	144,553	99,050
Ooregum	153,636	360,889	174,382	129,251
Hutti	26,170	75,000	.....	.....
North Anantapur	25,085	41,000	.....	.....

The last two in the above table are in other districts and are opening promisingly.

This country absorbs great quantities of gold and silver, in fact, it practically controls the price of silver in the world; and details of the movements of these metals in 1913 are given in the first part of th is section.

Japan.—There has been a gradual increase in the gold and silver output of this country, and that for 1913 was 7,281,411 yen and 5,708,975 yen respectively. The Sado is the principal gold-silver mine and treats up to 100,000 tons of ore per annum, containing 9 parts of silver to 1 of gold, or 1 1/2 oz. silver and $3 gold per ton. There is a fair equipment at this mine. Other gold mines are the Hasami, Ushio, Okuchi, Yamagano, Kinkwaseki, Botanko, and Dziuho. The most famous silver mine, also producing some copper, is the Ikuno. It yields up to 30,000 tons of ore containing $3 gold, 8 oz. silver, and 70 lb. copper per ton. Other silver mines are the Tsubaki and Innai, also the Kamioka, silver and lead. The Ashio, Besshi, Kosaka, and other copper mines produce a good deal of gold and silver as a by-product. In the island of Formosa, the annual output from about 10 lode and 30 placer mines is over $1,000,000; there was some increase in production here in 1913.

Korea.—The Oriental Consolidated Mining Co. worked its 240 stamps and cyanide plants throughout the year. There was a considerable shortage of water at times, and trouble with the electric-power transmission lines. Ore treated varied from 22,000 to 25,000 tons per month, yielding up to $145,000. Net profits averaged about $45,000 monthly. The Taracol tube-mill plant was shut down as being a technical failure, and the leaching method reverted to with better results. During the year ended June 30, 1913, the company's nine mines produced 313,701 tons of ore averaging $6.39 per ton. Mining cost $1.95 per ton. The total net yield was $1,629,324, being 89.4 per cent. extraction. After paying for operation and construction, etc., the net receipts were $571,384. Dividends for the year totaled $429,390. The surplus profit on hand at

June 30, 1913, was $926,557. Ore reserves in six mines were 805,900 tons containing bullion worth $4,488,800. The reports of this company are always given with commendable detail.

The Seoul Mining Co., operating the Suan Concession in Whang Hai province, has worked its 40-stamp mill, treating 71,535 tons in 1913 for gold worth $671,536. The profit was $376,363, and dividends were equal to 50 per cent. on the capital.

Details of the Suan Concession were described[1] by a general report made on the property by A. H. Curtis for the firm of Hooper, Speak & Co.

At the French Concession a 20-stamp mill and cyanide plant is in operation, at a profit of $15,000 to $20,000 per month. From January 1 to April 1, 1913, 5 stamps with a cyanide annex produced $39,887 gold. From April 1 to August 1 with 10 stamps the yield was $77,873 and from then to the end of the year 20 stamps were working. Further additions to plant are to be made.

The Furukawa Mining Co. obtained in October last official permission to work gold mines at Chyonmamyon and Nokoli, in Kusong district, North Pyongan province. Work on these mines has been begun by the company, employing some 20 Japanese and about 200 Korean miners. The experimental stage of the work will be, according to Gunsuke Iijima, who supervises the work, three years, and the cost is estimated at 500,000 yen.

The Hasami Gold Mines Co., one of the more important Japanese concerns, is now examining properties in Korea.

Philippine Islands.—The past year shows a considerable increase in the gold production over 1912. According to the Division of Mines, Bureau of Science, the output was worth $863,362.

The Syndicate mine, in Masbate, has just started operations, the mill having been completed in record time for this country, about 8 months. This is an all-sliming decantation plant, Hardinge ball and pebble mills being used instead of stamps and tube-mills. The Keystone Co., operating two Lane mills, has sent two shipments of precipitate to Manila; but so far it has not been learned what the recovery of bullion was, although it is said to be satisfactory. The Colorado mine continues its steady progress.

In the dredging fields, the new boat on the Umirai river is about to begin operations, and from the Malaguit encouraging reports have been received. The sixth dredge in the Paracale district is about to be constructed, and the output in 1914 from this district is estimated, to exceed £1,000,000. In the Cansuran district of Mondanao, hydraulic machinery for the Cansuran Co. is already being installed. Some difficulty

[1] *Min. Sci. Pr.*, CVII, 256.

has been experienced due to transportation troubles, but this will soon be overcome. The company is employing about 150 men.

Considerable prospecting has been carried on in the Agusan river basin.

It is planned to install an up-to-date plant capable of handling 80 tons of ore per day at the Benguet Consolidated. It is hoped that the plant will be in operation before January 1, 1916. The former mill on this property was washed away in the typhoon of October, 1909.

Australian dredging companies in the Philippines promise well, according to *The Bulletin*, Sydney. The Gaumus Co. is getting $38,000 worth of gold per month from gravel worth from 48 to 60 cents per yard. The Philippines Dredging Co. has 1000 acres, and is working one small dredge on 48-cent ground. Three other dredges are building to work gravel worth 24 cents per yard. Excellent prospecting work has been done by the Umeari Co., which has 1600 acres on the Umeari river lower than and adjoining a Manila company which is getting 96 cents per yard.

AUSTRALIA.—The territories grouped under this name include the six states of Australia, Papua, and the Dominion of New Zealand. Base-metal mining and production, which yields a large percentage of the gold and silver of Australia, was far more active than the mining of precious-metal ores. With the exception of Western Australia, the other states had a decreased output of gold, as shown below:

PRODUCTION OF GOLD IN AUSTRALIA. (a.)
(In fine ounces.)

State.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
New South Wales	253,987	247,363	224,792	204,709	188,857	181,121	165,295	149,657
Northern Territory	12,759	5,160	5,633	5,682	5,109	(e) 5,000	(e) 5,000	(e) 4,500
Queensland	544,636	466,476	465,085	455,577	441,400	386,164	347,946	263,343
South Australia	8,037	4,834	2,898	7,111	6,603	3,537	6,592	6,556
Tasmania	60,023	65,355	57,085	44,777	37,048	31,101	37,973	35,500
Victoria	772,290	695,576	671,208	654,222	570,383	504,000	480,131	434,932
West Australia (b)	1,736,295	1,671,993	1,596,091	1,576,406	1,422,231	1,338,987	1,282,658	1,314,044
Commonwealth	3,388,027	3,156,757	3,022,792	2,948,484	2,661,631	2,449,910	2,325,595	2,208,632
New Zealand (c)	534,616	477,312	471,967	472,465	446,434	427,385	310,796	343,627
Total Australia	3,922,643	3,634,069	3,494,759	3,420,949	3,108,065	2,877,295	2,636,391	2,552,259

(a) From official publications. (b) Production reported by the Mines Department; in previous volumes the statistics have represented exports. (c) Exports. (e) Estimated.

There being no mint in New Zealand, all of the gold is exported to Australia and London for coinage. Gold received for coinage at the Australian mints in 1913 was as follows: Melbourne, 555,321; Perth, 1,490,933; and Sydney, 540,283 fine ounces. The Perth mint is operating at a small profit, yet at only about 50 per cent. capacity. Dividends paid by Australian gold mines in 1913 amounted to £1,349,500.

Silver in Australia is mainly a by-product from lead and copper ores in New South Wales, Queensland, and Tasmania. There are no siliceous silver ores mined and treated in Australia as in the United States, Canada, and Mexico. The gold ores of Victoria and Western Australia contain little silver per ton, yet the aggregate amounts to a considerable weight. Ores from the North Island of New Zealand contain a high percentage of silver, and the output in 1913 was 975,591 oz., against 343,627 oz. of gold, a small proportion of the silver coming from the South Island mines, which yield gold worth up to $20 per ounce.

The silver output of Australasia last year was as follows:

PRODUCTION OF SILVER IN AUSTRALASIA.

State.	1911.		1912.		1913.	
	Ounces.	Commercial Value.	Ounces.	Commercial Value.	Ounces.	Commercial Value.
New South Wales (a)	14,529,145	$7,745,810	13,514,249	$8,157,131	14,504,889	$8,548,798
Queensland	549,015	273,642	569,181	322,336	604,979	333,020
South Australia	1,400	680	2,700	1,584	2,660	1,460
Tasmania	(e)700,000	373,100	(e)1,025,000	623,200	2,750,000	1,557,100
Victoria	19,147	10,397	17,424	10,714	16,671	9,952
Commonwealth	15,798,707	$8,403,629	15,128,554	$9,114,965	17,879,199	$10,450,330
New Zealand	1,310,943	698,733	(e)983,500	597,970	975,671	505,612
Total	17,109,650	$9,102,362	16,112,054	$9,712,935	18,854,870	$10,955,942

(a) Metal produced in Australia, plus silver contents of concentrates exported. (e) Estimated.

Some remarks on the work done in the various centers are as follows:

New South Wales.—This state has no great gold mines, and the gold production is the effort of a large number of small properties, by-product from copper mines, and a little from dredging. There were no important developments during the past year. The Mt. Boppy mine, in the Cobar district, is the principal gold producer, and in 1913 treated 64,762 tons of ore for 37,094 oz. bullion. Returns fluctuated considerably during the term.

The Great Cobar, Limited, which operates the Great Cobar, Cobar Gold, Chesney, and Peak mines, has been the cause of considerable discussion, and a change of management. Development has not been entirely satisfactory. During the past financial year the smelter treated 361,566 tons of ore yielding 27,136 oz. gold, 127,542 oz. silver, and 5811 tons copper. The gross profit was £81,926; but no dividends were paid. As regards other fields, the principal contributions have been drawn from the Adelong, Araluen, and Wyalong divisions. On the Wyalong field operations have not been conducted as vigorously as in former years; but, owing to the consistent returns being obtained from the True Blue mine,

the yield will probably exceed that recorded for the previous year. On the Hillgrove field, mostly development work has been carried out at the principal mines; consequently the production has been on a restricted scale. The dredging industry is still a material factor in the gold yield, and, although the returns from this source are less than in the previous year, the aggregate forms a considerable portion of the total production. The chief centers of gold-dredging operations are Araluen, Adelong, and Braidwood.

The great center of silver production is Broken Hill, which, in spite of labor and other troubles, has been the scene of great activity and increased production. The total output of the smelters at Port Pirie and Broken Hill, up to May 21, 1913, are as follows: lead, 1,354,034 tons; silver, 158,408,072 oz.; gold, 98,303 oz.; antimonial lead, 11,869 tons; spelter, 6,584 tons; leady concentrate, 1,261,980 tons; and zinc concentrate, 573,606 tons. During 1913, the silver output was about 14,000,000 oz. Development down to 1400 ft. was very encouraging in several mines. Mining, concentration, and flotation methods at Broken Hill were given full publicity by papers read at the annual meeting of the Australasian Institute of Mining Engineers, and published in its *Transactions*.

The Proprietary, South, Central, South Blocks, Block 10, British, and North, mines and mills were in operation, as well as the flotation plants of the Central, Proprietary, Zinc Corporation, and Amalgamated Zinc. Most of the zinc concentrate from these plants is sent to Europe at present. Australia, especially at Broken Hill, is the home of flotation processes. The Proprietary's lead smelting and refining plant at Port Pirie, South Australia, as usual handled the companys' own product and that from others on the "Barrier."

Queensland.—The past year's gold yield was 263,443 oz. worth £1,118,609, a decrease of 83,047 oz. and £352,761.

Dividends from gold mining companies amounted to £266,827, or £4606 less than 1912. Of this, Mt. Morgan distributed £200,000, and Charters Towers, £49,903.

A great deal of the gold and silver in this state comes from the smelting of copper ores. For instance, the Great Fitzroy produced 11,364 oz. gold and 20,830 oz. silver; Hampden Cloncurry, 1842 oz. gold and 50,651 oz. silver; Mt. Elliott, 5225 oz. gold and 6827 oz. silver; and Mt. Morgan, 113,696 oz. gold. The report of the last-named company for the half year ended November 30, 1913, shows that the smelters treated 148,924 tons of ore yielding 54,992 oz. gold and 4354 tons copper. The revenue was £496,936 and expenditure £324,090. Liquid assets amount to £588,482. The yield was lower than usual, but with the additions and

improvements to power, concentrating and smelting plants will show up during the current year. Ore reserves are 1,285,000 tons of high, and 1,960,000 tons of medium low-grade ores.

Mining at Gympie was quiet. The Scottish Gympie was examined by the government geologist, B. Dunstan, who favored certain development. During the year ended May 31,1913, the mill treated 85,700 tons for 22,303 oz. gold with a profit of £7700. Costs were $4.16 per ton. Development at 2100 ft. was not satisfactory.

After many years of struggling with complex copper-lead-gold-silver ores from several mines the Chillagoe company has stopped its smelter. Share-holders displayed great patience during the years of reconstructions and losses. The company controls an important railway.

Charters Towers mines produced 78,911 tons of ore yielding £306,899. The net results, dividends less assessments, totaled £12,024 for the year. The Brilliant Extended paid £18,750 in dividends. The ore deposits of this district occur as shoots in formation of the fissure type, there being a tendency to split and unite again. The mining men of Charters Towers wanted the Queensland government to advance £60,000 and sink a shaft 4000 ft. to test the field at depth, but after complete enquiry it decided not to do so.

South Australia.—A quiet year was experienced in all branches of mining in South Australia during 1913, and until fresh capital is introduced to give the much needed impetus, there does not appear to be an immediate prospect of an improvement in the condition of affairs. Numerous promising shows are lying idle for want of funds to continue prospecting and development work. Gold mining results were better than during the previous year, the result being an improved yield. Mining in the Northern Territory is still quiet, but more activity is expected now that the Commonwealth Government is helping prospectors. The output of gold in 1912 was £20,150, and that for 1913 will be about a similar amount. The director of mines for the area, which covers over 500,000 square miles, H. I. Jensen, published a report on mining during the year. Disadvantages are bad roads and transport, high cost of living and labor, dearth of skilled miners, exhaustion of the alluvial fields, picking the eyes out of mines, bad management, water troubles, and capital is hard to interest.

Tasmania.—The gold output from this state was 35,500 oz., a decrease of 2500 oz. compared with 1912. Of this the Tasmania produced 19,976 oz. from about 52,000 tons of ore; and Mt. Lyell, 7320 oz. from the smelting of about 250,000 tons of copper ore; the balance from other smelting operations and a little from alluvial mining.

The Tasmania mine at Beaconsfield has recently been examined by

engineers, and as a result all development is to be stopped, and the available ore extracted. This mine is extremely wet and has very large pumps at work, and is costly to work from this cause. The mill, cyanide and chlorination plants have been treating up to 5100 tons per month. The Zeehan district produced about 90,000 tons of ore for metal contents worth £270,000. The Tasmanian Smelting Co., at Zeehan, buys ore, and handled about 41,000 tons in 1913, and exported 4500 tons of lead, 520,000 oz. silver, and 7000 oz. gold. Mt. Lyell produced 344,601 oz. silver. About 450 men are directly employed in gold and silver mining, out of 6200 in all metals.

Mt. Lyell is back to its old stride again, and during the half-year ended September 30, 1913, gave 4050 oz. gold and 187,097 oz. silver from 153,869 tons of copper-bearing material, the copper being 2735 short tons. These precious metals are recovered from ores only averaging from 0.005 to 0.0275 oz. gold, and 1.33 to 1.96 oz. silver per ton.

Victoria.—This state's mines and dredges produced gold worth £1,847,400, a decrease of £192,000 compared with 1912. This was due to a general decline in all branches. The old Long Tunnel is practically shut down, work being done at 3225 and 3375 ft. on the incline, and sinking to 3625 ft. The Cassilis is in a transition stage; the deep leads are practically dead; Ballarat is quiet; the dredging returns have from lower, and this form of mining has been the cause of investigations through alleged damage to farming land, while Bendigo has been troubled with labor disputes, and the yields were lower.

In the latter center, deep mining has not been profitable, and better profits are made from the upper levels. The gold output in 1913 was 167,970 oz., paying £136,080 in dividends and £94,300 in assessments, against 174,901, £114,088, and £154,482, respectively, in 1912. Tributers worked in 35 mines. Some of the producers are as follows:

	Tons.	Ounces.	Dividends.
Central Red White and Blue	29,336	14,890	£38,400
Golden Pyke	13,909	10,647	23,415
Carlisle	20,986	6,730	12,600
Great Northern	9,794	5,206	9,750
South New Moon	16,066	6,439	9,600
Virginia	19,455	6,764	8,775
North Bendigo	10,004	3,970	7,200
Ironbark	14,677	5,593	4,958
New Chum Goldfields	11,408	2,577	4,000

Dredging was on somewhat the same scale as in 1912 when 55 bucket-dredges raised 16,777,591 cu. yd. averaging 1.7 gr. per yard. These had capacities up to 15,000 cu. yd. per week. Twenty-six hydraulic-sluicing plants handled 2,445,009 cu. yd. averaging 2.2 gr. per yard. Twelve jet

elevators treated 407,265 cu. yd. for 3 gr. per yard. Since 1900, placer mining has treated 185,254,860 cu. yd. for 2.2 gr. per yard.

Some of the yields in 1913 were as follows: The Porepunkah Dredging Co., at Bright, handled 197,100 cu. yd. during the last half of 1913 yielding 560 oz. gold. Three 24 cents dividends were paid. The Tongio Dredging Co., at Cassilis, treated 127,000 cu. yd. averaging 3.36 gr. per yard. A dividend of 24 cents per share was paid.

The Wallace properties, in the northeast of the state, of the Briseis Tin & General Mining Co., a concern operating tin properties in Tasmania, yielded 6492 oz. gold last year. Four dredges were worked, and handled about 122,600 cu. yd. per month. The Wandiligong Dredging Co. treated 265,893 cu. yd. during the last half-year for £30,200, while the Tewksbury Amalgamated in its six months handled 447,792 cu. yd. with four boats, yielding 6.30 cents, at a cost of 5.57 cents per yard. The profit was £690, while in its early years the company paid good dividends. Thirty dredges in the Bright district yielded gold worth £154,000 during the past three months, and paid £8900 in dividends.

Western Australia.—The regular decrease in this state's gold yield since 1903 was arrested in 1913, when that of 1,314,044 fine ounces was an increase of 21,386 oz. over the previous year. Since 1886, the total yield is 27,045,168 fine ounces. There were increases in the Murchison, North Coolgardie, Broad Arrow, and Yilgarn fields. In the first-named district the mines at Meekatharra are doing fairly well, these being equipped with small mills and cyanide plants, treating up to 3600 tons per month for £6200, in the case of the Queen of the Hills. The Victorious, 40 miles north of Kalgoorlie, owned by the Associated Northern Blocks, was practically a new producer in 1913, and treated 97,790 tons for gold worth £109,947 at a cost of 11 shillings per ton, during the year ended September 30, 1913. The Bullfinch added to its stamp-mill, and the 20 stamps are now treating 6330 tons for £14,300 per month with £9000 profit. The state government is diamond-drilling at Fraser's mine, Southern Cross, and the large low-grade ore-bodies may yet be profitable. Coolgardie is very quiet, the scene of activity being at Burbanks, where the Main Lode is the largest mine, but is now temporarily shut down. The district showed a decrease during the year. Kalgoorlie produces 60 per cent. of the state's output, and the well-known mines, namely, the Associated, Great Boulder, Horse-Shoe, Ivanhoe, Kalgurli, Lake View & Star, Oroya Links, Perseverance, and South Kalgurli, continued their usual development, ore production, and treatment. No great life is now expected from the Associated and Kalgurli, these being 2100 and 1850 ft. deep respectively. J. Malcolm Maclaren has decided that when the ore-bodies leave the quartz-dolerite and enter the calc-

schist, there is not much hope for profitable ore. The Ivanhoe shaft is down over 3000 ft., and extensive prospecting is to be done. The Horse-Shoe has had a better year and is now mining ore at 2780 ft. The Great Fingall and Sons of Gwalia, in the northern districts, are both opening in a promising way. The former is down 2500 ft., and the latter about that depth on the incline. Dividends paid by 18 Western Australian mines in 1913 totaled £906,637, and all mines £23,898,988 to date. The current year should equal that of 1913, but no new districts are being opened.

The geology of the Kalgoorlie field was thoroughly discussed by J. Malcolm Maclaren.[1] This is being followed by articles by C. O. G. Larcombe, whose work the "Geology of Kalgoorlie" is a recent publication. C. Gibson, a government geologist, also published a treatise on the field.

A feature of the work being done at Kalgoorlie, is the mining and profitable treatment of low-grade oxidized ore in small mines outside of the "Golden Mile." For instance, the Hannan's Reward produced 27,169 tons averaging $2.46 per ton in 1913.

The Great Boulder's reserves at the end of 1913 were 615,114 tons averaging $14.57 per ton, a decrease of about 37,000 tons, but about the same gold content. In 1913, 189,469 tons was treated averaging $13.98 per ton. The Ivanhoe's reserves to 2420 ft. total 991,417 tons averaging $9.24 per ton. The shaft is down about 3000 ft., and a good deal of pioneer prospecting is being done at depth, which at one time was done in the Great Boulder, whose shaft has remained at 2800 ft. for some time.

To the end of 1913 yields from the principal Western Australian mines were as follows, according to the *Monthly Journal* of the Chamber of Mines:

Name.	Short Tons.	Yield.	Dividends.
Associated	1,473,455	3,469,219	£703,833
Associated Northern, two mines	365,555	1,728,043	726,250
	124,287	137,349	.....
Bullfinch	53,427	169,389	23,807
Burbank's Main Lode	154,059	341,071	16,494
Golden Horse-Shoe	3,352,119	8,918,249	3,135,000
Golden Ridge	196,291	423,415	140,209
Great Boulder Perseverance	2,431,064	5,676,192	1,461,116
Great Boulder Proprietary	2,420,173	8,959,531	4,219,300
Great Fingall	1,851,091	4,615,231	1,746,875
Ida H	184,576	519,744	75,177
Ingliston Consols Extended	74,858	202,218	.....
Ivanhoe	2,847,066	7,620,919	3,188,750
Kalgurli	1,273,505	3,454,339	1,372,500
Lake View and Oroya Exploration	1,276,817	4,311,157	1,502,750
Lake View & Star	720,290	851,665	.....
Mararoa	178,634	354,939	100,000
Oroya Links (dividends include Brownhill Co.)	526,738	653,428	2,189,366
Sand Queen	51,867	158,984	35,250
Sons of Gwalia	1,915,726	3,724,868	892,863
South Kalgurli	1,565,159	2,408,524	260,780
Yuanmi (dividends include Oroya Black Range)	465,697	940,636	126,250

[1] *Min. Sci. Pr.*, CVI.

New Zealand.—All the gold and silver produced in this country is exported. In 1912, mines in both islands were affected by strikes, and the output was £1,345,131 gold and 801,165 oz. silver. This was from the treatment of 335,651 tons of ore, and includes £266,348 from the 87 dredges at work in the South Island. The past year, 1913, was fairly quiet as far as gold mining was concerned, although shareholders and employees suffered a good deal, and the yield was almost the same as in 1912. There were no important discoveries in the Hauraki peninsula in the North Island. This area produced bullion worth £860,448 in 1913, an increase of £80,313. In 1907 this was £1,421,216. Most of the silver produced in New Zealand comes from the Waihi and adjoining districts. The principal producers were the Waihi, 184,768 tons for £331,995; Waihi Grand Junction, 98,372 tons for £180,119; Talisman, 39,780 tons for £215,642; Crown, 15,299 tons for £29,070; and Waihi-Paeroa, 140,100 tons of tailing from the Ohinemuri river for £42,300. The Waihi Co. is developing at 1300 ft. Its new hydro-electric power line, 51 miles long, is in operation. The Grand Junction is developing fairly well, and an additional 20 stamps are being erected. Results at the Talisman were good. Deep-level development at 1000 ft., at the old Thames field, was disappointing. The total output of the district was £20,450. Coromandel was also quiet, and produced only £13,031. In the South Island, dredging in Otago and the west coast was about normal. The reopening of the Ross gravel mine at Westland, a rich old producer, attracted considerable interest. Water has always been troublesome. The Progress, Wealth of Nations, and Blackwater mines at Reefton worked steadily in 1913, treating up to 2900, 2200, and 4100 tons of ore worth about 24, 30, and 37 shillings per ton respectively. Mining costs are high, but treatment low.

CANADA.—The preliminary report, compiled by John McLeish, on the mineral production of Canada in 1913, shows a total production of $144,031,047, of which the gold output was $16,216,131, an increase of $3,567,337; and the silver output 31,750,618 oz., a decrease of 456,153 oz.

The Yukon placer production is estimated at $5,835,554 as against $5,576,493 in 1912, the total amount on which royalty was paid during the calendar year according to the records of the Department of Interior being 352,900 oz. in 1913, and 335,015 oz. in 1912. The British Columbia production was $6,136,900, of which the placer production as estimated by the provincial mineralogist was $540,000. Smelter recoveries and bullion from milling ores being estimated as $5,596,900.

The main feature of the year was the large increase from the Porcupine district of Ontario. British Columbia and the Yukon also show substan-

tial increases, while the estimates for Nova Scotia and Quebec show decreases.

The export of gold-bearing dust nuggets, gold in ore, etc., was valued at $12,770,838. Gold in bars, blocks, ingots, etc., were imported to the value of $840,435.

The estimated production of silver was 31,750,618 fine ounces, valued at $18,984,012, a decrease of 204,942 oz. and $456,153 from 31,955,560 oz. valued at $19,440,165 in 1912.

Of the 1913 production 28,452,737 oz. was from Ontario, and 3,208,122 oz. from British Columbia. For British Columbia the figures represent the recovery in mill bullion or as silver contained in smelter products, while for Ontario the figures represent the silver contained in gold ores milled or smelted, and in bullion shipments from Cobalt, to which is added the silver contents of the Cobalt ore and concentrate shipped, less 5 per cent. allowed for smelter losses. The total shipments of ore and concentrate from the mines of Cobalt and the adjacent districts were about 44,106 tons containing approximately 22,031,564 fine ounces in addition to which 7,482,833 fine ounces was shipped as bullion. Of this tonnage about half was treated in the camp itself in various reduction works. In Quebec the silver was derived from the pyritic ores of the eastern townships. The exports of silver in ore, etc., as reported by the Customs Department, were 37,371,569 oz. valued at $21,441,220. There was also an importation of silver in bars, blocks, sheets, etc., valued at $840,245.

British Columbia.—No hesitation has been felt in estimating that the yield of gold, placer and lode combined, has been larger than in 1912, according to Wm. Fleet Robertson in his annual report. For placer gold, a decreased production is expected, taking the province as a whole, of about $15,500, the output being $540,000 although the Atlin camp will show an increased production over last year; and for lode gold $5,509,526, equivalent to an increase of $187,000, has been taken as fairly representing the production of this metal, so far as indicated by the advices received to date. Dealing with these classes of gold mining separately, it may be observed: Practically all the placer gold is obtained in the Cariboo and Cassian districts, which contributed $190,000 and $320,000 respectively, the Atlin division being in the latter. The season here was favorable for all concerned. The gravel-washing season was shorter than usual at Cariboo. The large plants were not operated in the Quesnel division. The Stikine-Laird district is attracting attention, and the Boulder Creek Hydraulic Co. did well. There were "rushes" to Silver and Sibolla creeks during the year, but apparently they were not justified. There is no dredging in the province, although a boat is being constructed on the

Quesnel river. The estimated lode gold production was as follows: Rossland, 135,300 oz.; Boundary, 103,300 oz.; Nelson, 23,500 oz.; Coast, 3000 oz.; and Lillooet, 1300 oz. Of the Rossland total, 120,000 oz. came from the Consolidated Mining & Smelting Co.'s mines, and 15,000 oz. from Le Roi No. 2. The report of the former company for the 15 months ended September 30, 1913, shows that 407,124 tons of ore was smelted yielding 186,017 oz. gold and 3,224,408 oz. silver. Gold worth $802,330 was recovered from 70,796 tons of ore by the Nickel Plate mill at Hedley. Ore reserves total 413,000 tons. Also 40,500 oz. was recovered at the Granby Consolidated Co.'s smelter at Grand Forks, and 19,300 oz. at the British Columbia Copper Co.'s plant at Greenwood. The Portland Canal Tunnel Co. is still driving its long adit, but has cut some ore.

Silver production of the province was about 3,570,000 oz., an increase of 437,000 oz. over 1912. This came from Slocan, 1,860,000 oz.; Ainsworth, 487,000 oz.; East Kootenay, 413,000 oz.; Boundary, 380,000 oz.; and Nelson, 160,000 oz. The Standard mine, in the first-named district, produced about 66 per cent. of that output. In the others, the properties of the three smelting companies contributed largely.

Ontario.—Mining in this province in 1913 showed an increase of 9.5 per cent. over 1912, according to the report of Thomas W. Gibson. The gold output was valued at $4,558,518, and the production of silver was 29,724,931 oz.

There were 16 producing gold mines in 1913, seven of which were in Porcupine and nine elsewhere. The Porcupine mines yielded 207,583 oz. of gold, or more than 94 per cent. of the whole production. From the other districts the production was as follows: Kirkland Lake and Swastika 4183 oz.; Long Lake 5879 oz.; Larker Lake 700 oz.; eastern Ontario 1065 oz.; and northwestern Ontario 1262 oz. Much attention is being given to Kirkland Lake.

The silver production of Cobalt was a little less and in 1912 being 29,681,975 fine ounces, as against 30,243,589 oz., a decrease of 561,884 oz. or 1.85 per cent. High-water mark was apparently reached in 1911 when the yield was 31,507,719 oz. The process of decline is proving more gradual than did that of increase, the falling off in two years being only 5.7 per cent. The price of silver last year was lower than in 1912, the result was to reduce the return of the mining companies $853,934, the value of the output being $16,555,001. To obtain the total yield of silver, there should be added to the Cobalt output 42,956 oz., recovered from auriferous ores of Porcupine and other gold camps.

It is now ten years since the silver deposits of Cobalt began to be

worked and up to the end of 1913, their total yield has had a value of $98,286,116, the output aggregating 185,497,814 oz.

The shipments of ore and concentrates have ceased to be an index of the output of Cobalt, since so large a proportion of the silver is now produced in the form of bullion. The shipments for 1913 follow: Ore 9495 tons, containing 13,668,079 oz.; concentrates 11,017 tons, containing 9,014,633 oz., and bullion 6,999,263 oz. The silver refineries outside of Cobalt have been reduced in number by two, the plant owned and operated by the Canadian Copper Co. at Copper Cliff having been closed, and the works of the Canada Smelting & Refining Co. at Orilla having been burned down.

At Porcupine, during the 10 months of operation, the Dome produced 118,230 tons worth $1,047,606, equal to $8.86 per ton. In August it was $6.31, and May $13.68 per ton. The annual report of the Hollinger showed that 138,291 tons of ore was treated in 1913, yielding $2,471,273. Operating expenses were $843,159; dividends, $1,170,000; and surplus, $458,113. Ore reserves total 845,309 tons worth $11,604,000, against 644,540 tons worth $11,271,400 in 1912. Developments have been satisfactory at depth, both by mining and drilling.

The Tough-Oakes mine is at Kirkland Lake. From this property 101,049 tons of selected ore was shipped, which contained a gross value of $46,685 or $462 per ton. In addition 1975 tons of lower grade material were put through a small samp-mill and $26,232 in gold recovered, or $13.28 per ton. The veins at Kirkland Lake, which are quite narrow, are found in Temiskaming conglomerate and graywacke in contact with porphyry, and also in the latter. The Tough-Oakes and other claims have been acquired by English capitalists and the district is likely to be thoroughly tested.

The usual mining and metallurgical activity was continued at Cobalt. Prospecting by hydraulicking was satisfactory at the Nipissing. Its main shaft is down 900 ft., the deepest in the district. Kerr Lake was drained, and Cobalt Lake is being emptied. These areas should add considerably to the reserves of the district.

The following table shows the estimated production of the principal properties in the Cobalt district in 1913 compared with 1912. The total for 1913 is estimated for the last month of the year, and in one or two instances for the last 2 and 3 months:

Mine.	Gross ounces. 1913.	1912.
Nipissing	4,600,000	4,719,578
Conisgas	3,550,237	3,703,942
La Rose	2,623,000	2,920,344
McKinley-Darragh	2,250,000	2,704,868
Buffalo	2,000,000	1,890,150
Kerr Lake	2,109,975	1,895,309
Crown Reserve	1,833,333	2,714,766
Cobalt Townsite	1,783,554	1,505,396
Cobalt Lake	1,200,000	1,123,146
O'Brien	1,200,000	1,091,631
Sen. Superior	1,150,000	.....
Beaver	750,142	689,921
Temiskaming	735,000	1,242,243
Temiskaming & Hudson Bay	659,872	957,055
Trethewey	610,139	620,923
Penn. Canadian	365,000	.....

Dividends paid by Cobalt mines in 1913, were as follows, according to *The Daily Nugget:*

Company.	1913.	To date.
Beaver	$ 60,000	$ 410,000
Buffalo	890,000	2,527,000
Caribou-Cobalt	25,000	25,000
City of Cobalt	.....	139,321
Cobalt Central	.....	192,845
Cobalt Lake	240,000	240,000
Cobalt Silver Queen	.....	315,000
Cobalt Townsite	500,000	900,000
Conisgas	1,640,000	5,720,000
Crown Reserve	795,966	5,483,315
Foster	.....	45,774
Hollinger[1]	1,170,000	1,440,000
Kerr Lake	600,000	4,920,000
La Rose Consolidated	937,500	4,079,185
McKinley-Darragh	1,033,938	3,865,262
Nipissing	1,800,000	10,890,000
Right of Way	.....	526,903
Seneca-Superior	309,649	309,649
Temiskaming & Hudson Bay	162,981	1,870,341
Temiskaming	150,000	1,384,156
Trethewey	150,000	1,012,598
Wettlaufer	141,659	637,465
Total	$10,196,694	$46,935,718
La Rose (shared privately previous to May, 1908)		1,204,862
Private corporations (estimated)		3,500,000
Total		$51,638,681

[1] The Hollinger is at Porcupine.

Ontario is full of possibilities for gold, silver, and other mining, and the accompanying map shows the principal districts of the province.

Quebec.—The gold output of this province was worth $14,794, against $19,924 in 1912. Silver was 36,392 oz. worth $21,791, compared with $14,591 in 1912. The figures for gold and silver represent the contents of these metals in the copper and sulphur ores of the eastern townships. The Beauce placers were not operated during 1913.

Yukon.—The gold output from placer mining was $5,835,554 against $5,576,493 in 1912. This is mainly from the two following companies: The Canadian Klondyke Mining Co.'s dredges treated 6,363,515 cu. yd. of gravel in the season of 1913, yielding 85,899 oz. gold worth $1,331,000. Working expenses totaled $480,000, and the profit was about $750,000. Three boats with 16, and one with 7 1/2-cu. ft. buckets, were in operation.

No. 2 worked 268 days, a record for the Yukon and Alaska. They are all driven by electric power, generated by water from the Klondike river. Another boat may be constructed at the upper end of the property in 1915. Estimates of this company's gravel deposits show very large areas, and the North West Corporation's, the holding company, properties

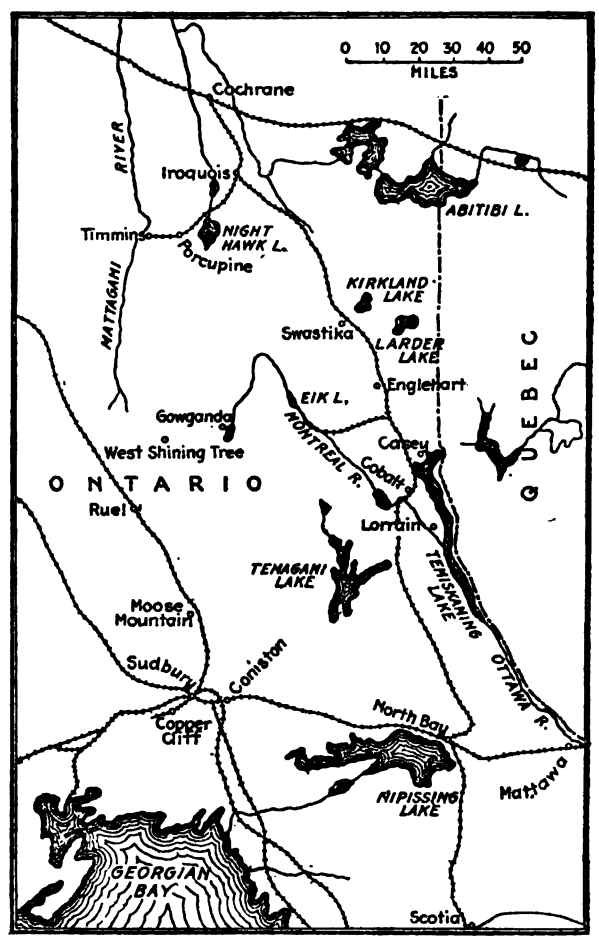


FIG. 2.—Principal mining districts of Ontario.

cover more than half of the best-known portions of the Klondike gold field, which has already produced nearly £40,000,000, according to A. N. C. Treadgold, the managing director. The area is 20,000 acres. Working costs are down to 10 cents per cubic yard. The areas contain about 600,000,000 cu. yd., about half have been proved, 100,000,000 cu. yd.

averaging 30 cents; and 200,000,000 cu. yd., averaging 20 cents per yard. The annual quantity to be treated eventually is 15,000,000 yd.

The Yukon Gold Co. operates dredges and hydraulic plants near Dawson, Klondike, dredges at Iditarod, Alaska, and a boat on the American river, California. The report of O. B. Perry for the year 1913 gives the following information: No. 4 and 6 boats in the Klondike were dismantled, and are being rebuilt on other areas. The cost of moving them and constructing power lines was $164,484. The eight Dawson boats worked from May 1 to October 31, a season of 164 days. The average recovery and cost was 65.13 cents and 29.53 cents per cu. yd., respectively. Owing to power troubles with the Granville Power Co. the boats were idle 20 days or 11 per cent. of the possible time. The power contract is to be cancelled, and power will be obtained from the Yukon Gold Co.'s own plant. Of the area mined at Dawson 445,624 sq. yd. or 68.4 per cent. was frozen, and had to be thawed by steam. The Iditarod dredge worked from May 8 to November 25, a season of 203 days. The average recovery and cost was $1.67 and 64.33 cents per cubic yard respectively. Hydraulicking at Dawson resulted in a loss, due to stripping the top gravel before the "pay" could be mined. The water supply fell from 524,249 miners' inches in 1912, to 406,135 in 1913. The area blocked out and stripped could not be completely mined and the gold recovered. About 50 per cent. remains to be cleaned to bedrock, so the gross value is not representative of the area mined, or of the gold content of the gravel. The cost was 9.7 cents per cubic yard, and duty of the water 6.6. Drought, using water for generating power, and a bad break in the ditch system were responsible for unsatisfactory hydraulic work. Scattered claims leased to individuals gave a good profit. Results may be summarized as follows:

Royalties paid were $787,278; amortization, $520,886; interest, general, $145,373, a total of $1,453,536. A dividend of 6 per cent. was paid. The indebtedness to the Guggenheim Exploration Co. was reduced by $425,000. The surplus at December 31, 1913, was $489,576.

Work Done.	Cu. Yds.	Gold Yield.	Cost.	Profit.
Dawson dredging	5,133,575	$3,343,667	$1,515,872	$1,827,795
Dawson hydraulicking	2,875,952	256,491	278,917	22,426[1]
Iditarod dredging	496,756	827,420	319,560	507,860
California dredging	2,550,271	176,023	103,849	72,174
Miscellaneous	.....	185,800	33,756	152,044
Total	.....	$4,789,403	$2,251,955	$2,537,449

[1] Loss, due to causes explained.

Mining in this continent in 1913 presented accumulated evidence of the important development work of the past few years. This

was so, more especially in copper properties, which have shown great tonnages of profitable ore. Although enormous quantities of gold and silver have been recovered in this country, yet the present output is only about 3 1/2 and 6 1/2 per cent. respectively of the world's annual yield; but it should increase steadily in the future. American and British mining companies were active during the past year and investigations were carried on in Peru, Brazil, British Guiana, and Colombia. In the first two countries examinations resulted unfavorably. South America is one of the few fields for dredging possibilities that has not been exhaustively examined.

Brazil.—The most important gold mining in this republic is at Morro Velho mine, at Minas Geraes, and owned by the St. John Del Rey Mining Co. of London. The fifty-fifth half-yearly report shows that the ore reserves total 1,045,912 tons or 5 1/2 years' supply at 192,000 tons per annum. The mine is opened to below 5000 ft. on the incline. The labor situation was serious, but is improving by the importation of Japanese. The various plants worked well, and the 120-stamp mill treated 82,500 tons of ore in 138.3 days, yielding $950,000, with 92.63 per cent. extraction. The profit was $259,000, and dividends $120,000. Investments on the reserve fund were $460,000, and mortgage bonds outstanding $134,000. This company also controls extensive deposits of iron ore.

The Diamond King Mining Co. has a dredge working at Mendanha, in the Minas Geraes country. Diamonds are also recovered.

The Ouro Preto Gold Mines of Brazil, operated throughout the year and was crushing in the autumn nearly 6000 tons monthly with a yield of about $5.88 per ton. The Conquista-Xicao Gold Mines, Ltd., of 48 Avenida Rio Branco, Rio de Janeiro, installed at Campana, Sao Paulo, a 1000-h.p. hydro-electric plant and hydraulic equipment, including several giants, three 15-in. centrifugal pumps for sluicing, pipe-lines, and about 1 mile of steel sluice-way, using a high-carbon steel plate as a wearing plate within the frame of the steel sluiceway. The company began sluicing in the autumn of 1913, but up to date no report of the results of operations have been received.

British Guiana.—In this colony, where the gold production has declined for several years, more gold was sent out in 1913 than previously; due to the numerous small hand operations, which are known as "porknockers," and the placers of the Aujuni district.

The Guiana Gold Dredging Co. operates four boats on the Potaro river. In 1912–13 the output was $174,570 gold, and a 10 per cent. dividend was paid. The Minnehaha Dredging Co., on the same river, recovered 2472 oz. A new dredge may be built this year.

Canal Zone.—Placer claims in this district were examined by the official geologist, D. F. MacDonald and gave only from traces to 7.5 cents per cubic yard. He reported that the territory has practically no value for mining purposes.

Colombia.—Mining in Colombia received a great impetus in 1913 from the remarkably successful operations of the Oroville Dredging Co.'s Pato dredge, and from the decision of the Anglo-Colombian Development Co., a Consolidated Gold Fields of South Africa subsidiary, to proceed with its operation in the San Juan gold-platinum district. The

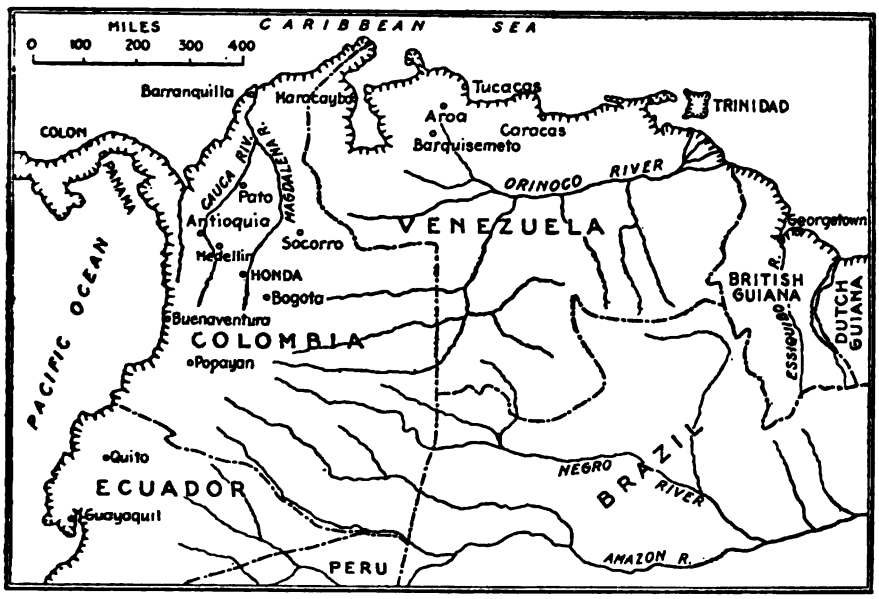


FIG. 3.—Colombia.

definite entrance of two great mining interests in this country, and the practically assured success of their operations will give new enterprises in this country a *cachet* they have lacked for years, and have already had the effect of directing the attention of other large mining operators to the great placer deposits of this country. Colombia is not without lode-mining possibilities, but the lack of transportation, except by rivers, will prevent for years any general development of the lode mining, whereas the country already gives evidence of becoming the world's next great placer field.

Considerable interest was manifested in the dredging operations of the Pato dredge, and a boom in the shares followed the announcement that recoveries for the first few weeks were above the average from pros-

pecting the "tested" area. To November 11 this was 315,212 cu. yd. for $205,267 or 65 cents per cubic yard. Previous to reaching this ground, 473,500 cu. yd. averaged 3.5 cents per yard. The ground dredged for the whole of 1913 was about 480,000 cu. yd., yielding $365,000. The estimated profit to be made from the Pato is £350,000. Other areas may be profitably sluiced. The Certigue Dredging Co. worked on the Certigue river and handled 22,700 cu. yd. for $7000 in gold and platinum. A 5-ft. boat is working profitably on the Pochet property. The American Goldfields Development Co. will erect a dredge in 1914 on the San Juan river to recover platinum. The Pochet dredge operated at a fine profit on the east bank of the Nechi river, below Zaragoza. Other properties were examined and worked by the Vallecitor Hydraulic, Sambenigno Mines, McGuire Bros., Breitung Mines, Rio Grande, Colombian Gold Mines, and other companies in many districts. The accompanying map shows the northwest part of South America.

Costa Rica.—The three leading mining properties in Costa Rica, the Abangarez, Aguacate, and La Union, had a year of successful development in 1913. La Union, one of the oldest properties in the Republic, was in bonanza ore and it is understood was able, without interfering with the mine production, to devote part of its attention to the dumps, this material being treated in the cyanide plant.

The Abangarez Gold Fields Co. on the western slope, reports as follows for 1913: Ore treated 69,346 tons, yielding $579,236, a loss of $22,040. Betterment expenses were $72,733. In 1912 the loss was $128,683, and betterment expenses $222,781. By May, 1914, there will be 60 stamps at work, crushing 12,000 tons per month. The outlook for the Aguacate is promising. An ore-body 1500 ft. long has been opened between No. 5 and 7 levels, and will average $20 per ton for a width of 5 ft. The ore is a honey-combed quartz containing considerable manganese dioxide. The mill contains 10 stamps and a leaching plant.

Dutch Guiana.—The government of this colony recently published the gold output for 1913, which amounted to 856,768 grm. (27,640 oz.), against 716,487 grm. (23,110 oz.) in 1912. About 90 per cent. of this gold was produced by hand methods. At present there is one small Chilean mill and one small dredge working in the colony. There will be another boat operating early in March, 1914. All gold produced in this country must pass through the government, which collects 5 per cent. of it. The figures given are quite reliable.

The gold placer mining of the territory was described by J. B. Percival,[1] who said that there is at present an excellent opportunity for investment of capital in Dutch Guiana. Gold is found in almost every

[1] *Min. Sci. Pr.*, CVI, 688.

part of this country, from the Corantyne river on the west to the Maronic on the east.

An important event in the Guianas was the building of an all-steel dredge on the upper reaches of the Rivière Approuague by the Compagnie francaise de Mataroni; the dredge has bucket of 150 liters (5.3 cu. ft.) capacity, and began digging in October; it was started in ground estimated to run 1 to 1.3 grm. per cubic meter.

Ecuador.—The most important mining operation in Ecuador is that conducted by the South American Development Co. Its mines are situated in the extreme south of the Republic, in the district of Zaruma, about 50 miles from the Pacific port of Puerto Bolivar. This gold-mining enterprise furnishes employment for about 500 men. During 1913 development was vigorously continued, and the 40-stamp mill and cyanide plant were in operation throughout the year.

Honduras.—The principal mining interest in this republic is the New York & Honduras Rosario Mining Co., at San Juancito, where the company operated its property at increased capacity, owing to improvements made in 1912. The new mill, comprising twenty 1800-lb. stamps and an all-sliming cyanide plant, was started in August, 1912, and has worked satisfactorily since that date, the tonnage being gradually increased until at the end of 1913 about 8500 tons are being handled monthly. During the year, mining by the shrinkage system was inaugurated and the management installed a number of B.C. 21 Ingersoll-Rand stoping drills, as it was impracticable to mine by hand the tonnage required by the new mill. The production in 1913 probably amounted to 75,000 tons, and the yield about 10,500 oz. of gold and 1,500,000 oz. of silver. The company has had in hand in 1913, a complete geological study of its property.

According to A. D. Akin,[1] in the Olancho district of this republic, there are good opportunities for placer mining. This has been done for many years in a desultory fashion.

Nicaragua.—The Camp Bird, Ltd., has taken an interest in five groups of mines in this republic, known as the Bonanza, Mars, the Lone Star, Siempre Viva, and Colona. The Bonanza and the Mars have mills and plant of 75-ton daily capacity and have, during the past 10 years, produced over 200,000 tons of ore at a yield of about $1,920,000. Operations, being handicapped by lack of funds and by expensive transportation, have only been on a small scale, the light equipment not being sufficient to treat the hard material after exhaustion of the soft surface ores. An exhaustive examination of these properties was made, and the purchase and further development was recommended. The aggregate

[1] *Min. Sci. Pr.*, CVII, 49.

length of known ore-shoots in these groups is 20,500 ft., the average width of the veins being about 15 ft., and that there are now in sight above drainage level approximately 2,400,000 tons of positive and probable ore, all of which can be mined by means of open cuts and adit levels, of an average grade of $6.66 per ton, from which a profit of $5,000,000 should be obtained. There is no payment for working the bond and lease of the claims for a year, only a rental of $6000 per month. Provided all titles are clear, the syndicate must pay $369,000 at the end of the first year, and if all is satisfactory the balance of $753,600 is to be paid a year later.

Near Matagalpa the Oroya Leonesa, Ltd., operated its mine and 20-stamp mill and cyanide plant. At October 31, 1913, ore reserves were 85,744 tons worth $9.80 per ton. During the first half of the year, work was interrupted by the customary revolution, and 11,715 tons yielded gold worth $72,000.

Peru.—Much outside interest has been taken in the development of the gold industry, although this continues to be unimportant if no regard is taken of the gold derived from copper and, to a less degree, from lead ores, according to Lester W. Strauss, in the *Mining and Scientific Press.* Activities in vein mining are increasing, although no large properties are in operation, while the placers are, as yet, smaller producers.

The largest producing property is that of the New Chuquitambo Gold Mines, Ltd., 6 miles below Cerro de Pasco. The production for the year ending November, 1913, was 114.34 kg. (nearly 3700 oz.) of bullion (over 900 fine), which represents a recovery of 65 to 70 per cent. effected by amalgamation from the treatment of 80 to 100 tons of ore per day in the 40-stamp mill; 140 men are employed in the mine and mill.

The Cotabambas Auraria, at Cochasayhuas, in the Department of Apurimac, has increased its production since the cyanide plant for coarse sand has been in operation. The present 10-stamp mill, one Huntington mill, and two Ferrarris tables, treating 16 tons of sorted ore per day, is to be increased with 40 additional stamps and a cyanide plant of adequate capacity, so that 100 tons can be milled per 24 hours.

Another probable increasing producer is the Sociedad Aurifera Andaray Posco, in the Department of Arequipa. The present plant consists of two Lane mills and a new cyanide plant.

In the Department of Puno, the Santo Domingo mine, of the Inca Mining Co., with a past record of £700,000 production, has been optioned to an Argentine syndicate for £120,000.

The production from the alluvial deposits is still small, disregarding that resulting from the native washings. The only company that has operated continuously and profitably is the Compañia Aurifera Argentina-Peruana, at Viscachani, Department of Puno. In the same province, the

Aporoma Gold fields, Ltd., has not been as successful as was anticipated. On account of the lack of water, operations were very limited. About £25,000 is needed for an additional ditch line, according to the company's statements, that would permit bringing in sufficient water to wash at least 10,000 cu. yd. per day. The 42,500 cu. yd. washed, during the initial working, showed a recovery of 7.3d. per cubic yard.

The most important silver property, other than those which ship argentiferous copper or lead products or ores, is the Sociedad Explotadora de Caylloma, in the Department of Arequipa. A concentrating and cyaniding mill, of 100 tons capacity per day, will be erected and ready for operation early in 1915.

Salvador.—The precious-metal production of Salvador in 1913 amounted to about $800,000 in gold and $300,000 in silver, this output being principally from the Butters properties in the departments of La Union and Jocorro. At the Butters Salvador Mines, Ltd., the capacity of the filter-plant was doubled in 1913, and operations increased generally. At the Butters Divisadero Co., at Divisadero, in the department of Jocorro, plans were made for increasing the mill capacity, and further mine equipment was ordered. The output at the Divisadero mine is about 700 tons per day, while that at the Salvador is between 800 and 900 tons per day. The Butters Potosi Consolidated Mines, Inc., is the title of an interesting development operation, where favorable results were obtained during the year and it is likely that an equipment will be put upon this property.

Besides the Butters operations, which are the principal ones in Salvador, Mackay, Pullinger & Co. placed some small equipment on the Encuentros property in the department of Morazan. Some work was done during the year by the Comacaran Gold Mining Co., near Jocorro but in the department of San Miguel. Additional equipment was added by the Monte Mayor Mining Co. in the department of La Union.

Venezuela.—There is a fair amount of mining activity here, but owners find it difficult to get sufficient labor, on account of the miners being able to recover gold by panning river gravel and stealing it. The class of labor is poor, being chiefly composed of negroes from the West Indies.

The Rio del Oro Co., Ltd., operating El Amparo mine in the Yuruary river district in the State of Bolivar, sank its main shaft to the 200-ft. level; the production for October was 120 tons, containing 518 oz. Mining concessions were granted to Augusto Pinaud for La Victoria and El Choco gold mines, in Roscio district, in Bolivar. The South American Copper Syndicate of London shipped regularly from its Oroa group of mines.

EUROPE.—There is not a great deal of direct gold and silver mining in Europe, save in Russia, which includes Siberia in this section, most of these metals coming from the reduction of lead and copper ores. Some attention is being directed to the Balkan countries, and the Ottoman Empire, since the recent war. The mines of the latter country were described by G. Maitland Edwards,[1] who stated that, regarding gold mining, the metal is not found so frequently as the mineralized state of the country would lead one to expect. There are ancient workings in Asia Minor; but generally little is being done at present. The Bereozovsk gold deposit of the Ural district, Russia, was described by Chester Wells Purington.[2]

Austria.—The Asgard Mining Co. was registered February 16, 1909, to acquire from J. W. Burkitt, the Mount Roundny gold mines and plant, in the communities of Barkowitz, Siboun, Laby, and Zvestoe, Bohemia, formerly the property of the Mount Roundny Gold Mines, Ltd. The report for the period from July 1, 1912, to June 30, 1913, shows that 32,125 tons was milled, yielding 718.40 kg. of amalgam and 6997 oz.; 582 tons of concentrate yielded 1882 oz.; and 15,864 tons of tailing cyanided, gave 243 oz. of fine gold. The total yield was 9122 oz. fine gold. The average working cost was $4.52 per ton. The ore reserves are estimated at 126,620 tons, the maximum average being $17.50 at the 250-meter level, and are estimated to contain 52,205 oz. of gold. The receipts for gold and silver, including gold in transit, amounted to £39,307. The credit balance for the year was £9617. Three dividends of 12 cents per share have been declared.

France.—The La Lucette mine, at Genest, in the department of Mayenne, is shut down. It has produced about $550,000 in gold for a number of years, also a great deal of antimony. France still has notable gold mines, such as La Bellière, Le Chatelêt, and others, but the passing of La Lucette is much to be regretted.

Great Britain.—Gold mining was restricted to operations on a prospecting scale, only 170 tons of ore being treated, evidently specimen, as the return is estimated at 1200 fine ounces; adding the amount of gold contained in copper ore, 144 oz., the total yield is 1344 fine ounces. Copper pyrite yielded 334,425 oz. of silver; also 3988 oz. from domestic copper ores, 118,540 oz. from domestic lead ores, and 182 oz. from domestic zinc ores, giving a total production from all sources of 457,135 oz.

Norway.—The total amount of silver produced at the Kongsberg mines during 1913, was 8459 kg. of fine silver and 1137 kg. in ore, valued at $183,000.

Russia (By J. P. Hutchins).—The production of gold for 1913 is variously estimated as being worth from $25,000,000 to $30,000,000.

[1] *Bull. 111, Inst. Min Met.* [2] *Bull. 112, Inst. Min. Met.*

Official figures are not yet available. The actual production is probably worth over $30,000,000, for a considerable proportion of the total gold is won in Eastern Siberia by Chinese, Koreans, and Russian Khishniki, or snipers and tributors. Much of this gold does not pass through the government offices, but is surreptitiously taken to China. Thus probably one-third of all the gold won in Eastern Siberia, which is 70 per cent. of the total Russian production, is not recorded as such.

More than 16 per cent. of the total gold production of Eastern Siberia is produced by one company; the Lena Goldfields, Ltd., operating the Lenskoie gravel mines; this is about 11 per cent. of the total gold produced

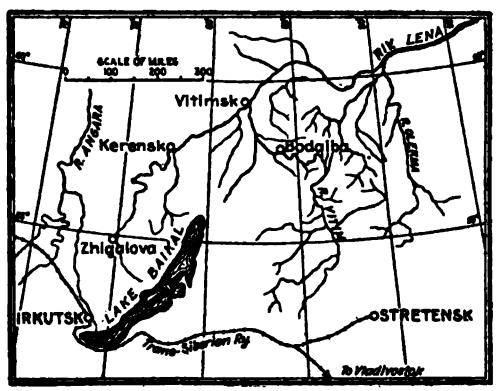


FIG. 4.—Lena River Goldfields of Siberia.

in the Russian Empire. During the year ending September 30, 1913, revenue amounted to £672,499, made up of £81,270 cash balance from the previous term, £378,664 from Lenskoie Gold Mines Co.'s shares sold, £178,629 from Lenskoie dividend, and, £33,936 from interest and royalties. The Lena Goldfields paid £266,648 in dividends, etc., and has a cash balance at September 30 of £405,851. The company holds 61.20 per cent. of the Lenskoie company's stock. The Lenskoie, the operating company, mined 820,189 cu. yd. of gravel, yielding 335,348 oz. gold, against 549,244 cu. yd. and 260,505 oz. gold in the previous year. The total production of the different groups of claims since the commencement of operations is 4,746,511 oz. gold, as given in the report of Charles M. Rolker. Out of 950 drill-holes, 69 average over 7 dwt. per yard. Probable reserves are as follows: stream length, 30,275 ft.; gravel content, 2,438,424 cu. yd.; total gold content, 946,230 oz.; net profit, 187,003 oz. Doubtful reserves have a stream length of 15,687 ft., containing 682,722 cu. yd. of gravel and 180,714 oz. gold, on which there would be a loss of 24,266 oz.

Of the total gold won in the Russian Empire, Eastern Siberia east of Lake Baikal, produces about 70 per cent.; Ural Mountains' region about 16 per cent.; Western Siberia, that is, between the Ural Mountains and Lake Baikal, about 12 per cent.; and about 2 per cent. is recovered as a by-product in copper refining. Practically all the gold won in Eastern Siberia, 30 per cent. of that from the Ural Mountains' region, and about 55 per cent. of that from Western Siberia, is from placers. These figures indicate very well the present insignificance of gold vein mining in Siberia. There is not now one large quartz mine in the Russian Empire.

There is the prospect, however, of there being developed some large gold mines in the Altai region. There are many old mines that were worked in prehistoric times in the Altai Mountains' region for silver principally. The occurrence of gold was recognized, but not appreciated, and so large bodies of high-grade gold ore were left in the mines. There is one large gold mine, the lower 450 ft. of which have been flooded since 1805. This is now producing ore for a small stamp-mill; but it is expected that it will be equipped with a large mill and modern treatment. There are hundreds of thousands of tons of ore containing about 10 dwt. gold per ton in the mine and which was not considered profitable by the former miners.

That part of Mongolia which has recently come under Russian influence, is being considered and will be investigated during the present year. The placers are in part perpetually frozen; there is frozen ground in Mongolia in latitude 48° north.

The Urals gold refineries during 1913 produced 110,000 oz. gold worth £399,208. The most productive districts were South Ekaterinburg, Orenburg, and North Ekaterinburg. Mining was more active and the yield 9072 oz. greater than in 1912.

The output of silver is on the increase, and the Urals output was about 600,000 oz., mainly as a by-product from copper and lead ores. The leading producer is the Kyshtim Corporation, returning 50 per cent. of the silver output of this part of Russia. In other districts, silver is principally obtained from mines in the Altai mountains, Siberia. These contain silver, copper, lead, zinc and gold. There are two groups, the Zmeingorsky and Salari mines. The Nerchinsk silver ores in Eastern Siberia yield about 29,000 oz. per annum. Silver works in the Kirghis Steppes are primitive. In the Caucasus the Alagir works are owned by a Belgian company.

There were 58 gold mines operated in the Orenburg district of Russia in 1912, from which was mined about 170,000 tons of ore yielding approximately 43,000 oz. of gold.

Mexico

By E. H. Leslie

The mineral industry of Mexico during 1913 labored under the handicap of civil war, banditism, and unrest with all of the accompanying impediments. In those out-of-the-way districts of Durango, Chihuahua, Coahuila, Sinaloa, Guerrero, Pueblo, Oaxaca, and Zacatecas the results of the present civil war were particularly felt due to the lack of transportation facilities, shortage of labor, and the continual subjection of properties in these districts to the attacks of bandits, who conducted marauding operations under revolutionary colors. While very little actual damage

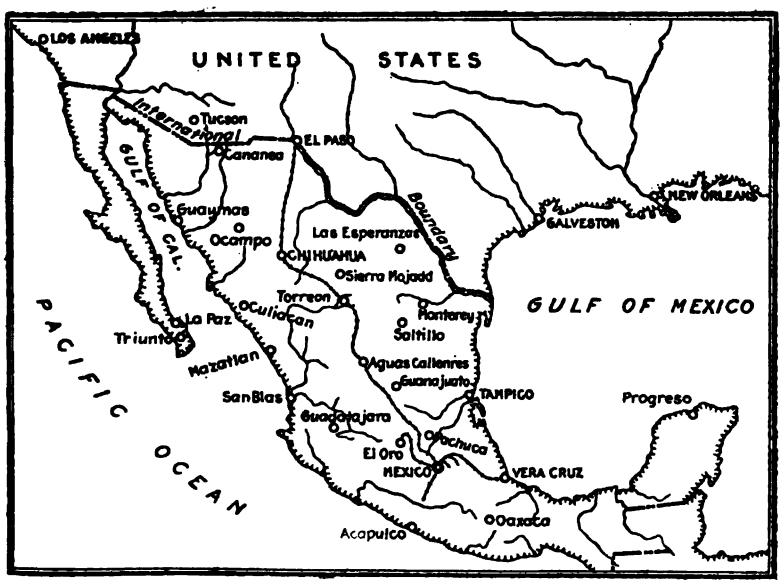


FIG. 5.—Mexico.

to mining property resulted, the effect has been the suspension of operations, with its attendant loss to share-holders, and a demoralization of the mining industry of that country in general.

The general decline in the gold and silver production during the past year is evidenced by the decline in the exportations which is generally considered as a true barometer of production. The statistics of the fiscal year ended June 30, last, give an increase in mineral products exported, compared with the fiscal year 1911–12, of pesos 3,441,807, but the increase in petroleum exports alone was approximately 10,000,000 pesos, and silver coin to the value of 9,806,402 pesos, an increase of over 9,000,000 pesos was

sent out of the country. The total of gold exported in the last fiscal year was 39,591,427 pesos , a decrease of 10,313,687 pesos; and of silver 91,239,-652 pesos, an increase of 1,725,298 pesos. Exclusive of the silver coin exported, there was a decrease in silver shipments of over 7,000,000 pesos. Copper exports totaled 36,522,115 pesos, an increase of 3,020,242 pesos, and lead exports 4,907,334 pesos, a decrease of 1,111,811 pesos. The zinc shipped had a value of only 536,094 pesos, a decrease of 372,600 pesos, and the exports of antimony amounted to 1,575,499 pesos, a decrease of 152,-839 pesos. The gold exported in the fiscal year included 868,815 pesos in Mexican and foreign gold coin.

The production of gold and silver since 1900 is given in the following table. While exact figures are impossible, the statistics presented are approximately correct, and show the general trend of the industry:

PRODUCTION OF GOLD AND SILVER IN MEXICO.
(Fiscal years ending June 30.)

Year.	Gold.		Silver.	
	Kilograms.	Pesos.	Kilograms.	Pesos.
1900-01	13,810	18,413,381	1,816,605	74,326,406
1901-02	14,706	19,607,967	1,772,724	72,530,983
1902-03	14,904	19,872,148	2,023,922	82,808,783
1903-04	17,082	22,775,815	2,013,383	82,377,546
1904-05	21,306	28,407,313	1,931,985	79,047,148
1905-06	27,307	36,409,368	1,849,956	75,605,605
1906-07	27,423	36,563,898	1,756,704	77,088,827
1907-08	30,395	40,527,185	2,151,014	85,366,904
1908-09	33,661	44,881,621	2,291,261	77,076,097
1909-10	36,222	48,295,508	2,257,363	76,371,884
1910-11	37,112	49,481,956	2,305,094	80,878,739
1911-12	36,415	48,553,632	2,493,731	89,628,435
1912-13	29,843	39,591,427	2,280,000	91,293,652

NOTE.—1 kg. = 32.15 oz. 1 Peso = $0.50 U. S. currency.

While these figures show an increase for the past fiscal year, the actual production shows a decrease as previously stated. The large amount of coin exported is largely attributed to the excessive rate of exchange, which made the silver in coin worth more than the face value of the coin.

The smelters have been laboring under difficulties through lack of transportation facilities, with the accompanying shortage of fuel and supplies. The Torreon, Velardeña, and Matehuala smelters were forced to close during the first half of the year, and have been unable to resume operations. The Chihuahua smelter has been running intermittently, while that at Agnascalientes has been running continuously, but at greatly reduced capacity. The Town smelter, at San Luis Potosi, was able to operate until August, when inability to get coke caused a shut-down for 2 months, and in December it was again forced to suspend operations. At Cananea, the copper company's smelter has been in continuous opera-

tion at varying capacity, although at times the company had difficulties in keeping the labor at the plant due to revolutionary enthusiasm. During the present year, 1914, the smelters that were struggling alone have suspended operations, and will abide a more auspicious time for resuming.

It is impossible with the space afforded in a publication of this nature to give anything but a brief resume of actual mining operations as to results which are being obtained by the different companies. However, a few notes as to what some of the more important producers are doing will serve as an index to the general status of the industry.

Chihuahua.—This state has been the stage for the greater part of the revolution, and as a result, its mineral production has been greatly curtailed. The impossibility of securing supplies and of shipping products forced many Chihuahua mines to shut down in 1913. Operations in the Santa Eulalia district of Chihuahua were well maintained, considering conditions, the ores supplying the Chihuahua smelter. Suspension of traffic on the Mexico Northwestern railway stopped shipments from the mines of the Cusihuiriachic district. The Alvarado Mining & Milling Co. continued operations in the face of great difficulties, and made shipments of bullion by wagon-train to the border.

The Mines Co. of America, which operates mines in Chihuahua and Sonora, reports as follows concerning the year's results: Development in the Dolores showed good results, and reserves at the end of the year were 100,932 tons, assaying $14.18 per ton. Costs were reduced by $2 per ton treated. Owing to bandits, the mill was stopped on September 1, and the mine 3 weeks later. El Rayo was forced to suspend work on July 10, but expects to resume shortly. Mining proved the extension of the known ore-bodies. Reserves are 54,800 tons of $14.60 ore. The Creston-Colorada and Grand Central produced 130,664 tons of ore worth $810,514. At the beginning of 1914, ore reserves were estimated as 306,300 tons, averaging $5.33 per ton. The Grand Central promises to be a profitable investment. Both mines and plants operated con inuously during 1913. It is proposed to increase the monthly output from 10,000 to 18,000 tons of ore. From the Gloria and Prieta mines at La Dura, there were produced 4869 tons. The stoping operations carried on in these properties have proved the persistence of the veins. The Gloria vein, below the 900-ft. level, is showing strong and yielded a good grade of ore, while on the 1040-ft. level of the Prieta mine, stoping shows a good tonnage of high-grade ore. Ore reserves are 23,229 tons, assaying $44.24. Partly on account of the interruption to railway shipping facilities and partly on account of President Wilson's proclamation urging Americans to leave all isolated camps in Mexico, operations were suspended in September. The property is in charge of the *presidente*

of the town, and has not been molested in any way. It is the intention to resume operations upon the re-establishment of railway communication. Ore reserves in all the mines are estimated to be 485,261 tons assaying $4,888,605, compared with 334,876 tons assaying $3,612,010 at the close of the preceding year. The production of the company's mines was 207,085 tons worth $2,017,057. Revenue was $1,734,626; operating profit, $495,987; and net profit, $467,232. The consolidated balance sheet of the company shows current assets of $1,539,378, accounts and drafts payable and suspense account $392,065.

The Batopilas Co., which is one of the oldest and largest of the state, reports as follows for the year ended December 31, 1913: total revenue, 742,568 pesos; expenditure, interest, etc., 582,473 pesos; profit, 160,095 pesos. There is a surplus of 194,913 pesos, an increase over the previous year. Cash totals 58,027 pesos; current liabilities, 46,260 pesos; and current assets, 174,372 pesos.

The San Toy Mining Co. had a gross income of pesos 317,332 with a surplus of 17,428 pesos during the year ended December 31, 1913.

The Buena Tierra Mining Co. makes the following report to the shareholders: Owing to the strife in the republic which has prevailed throughout the year, the management has been faced with unexampled difficulties. Railway communication has been suspended; labor has been both inadequate and unruly; the smelter to which the ore is sold was unable to operate continuously, and has been shut down since November 1 last. The development of the mine has been continued as opportunity offered, and has, the circular states, been quite satisfactory. It is estimated that the ore reserves at December 31 will equal the amount exposed last year—namely, 300,000 tons. For the 10 months ended October 31, 25,972 tons of ore were shipped to the smelter, realizing a profit over all outgoings of £19,800. Adding to this interest received in London, and deducting the estimated mine costs for November and December, as well as London expenses, provision for income tax, and so forth, there will remain approximately a net profit for the year of £16,000. With the amount brought in the balance to the credit of profit and loss account is about £22,500.

Coahuila.—This has been the chief coal-producing state of Mexico and during the past year due to rebel activities it has been necessary to practically abandon the mines. Shipments were stopped with the cutting of railroad communication in Coahuila, early in the year, but a number of the concerns continued operations for a time and accumulated big reserve supplies of coal, which were burned when the mines were dynamited by the rebels. The gold and silver production of the state was practically *nil.*

Durango.—This state has been a particularly keen sufferer from revolutionary activities and mining in the state is practically at a standstill. The Guanacevi district is producing nothing. The Peñoles Co. has been forced to practically suspend operations. The Bacis Gold & Silver Mining Co.'s property has suspended operations and the stores have been confiscated by the rebels. It is hoped that when the railway to Tepehuanes is in operation again under rebel control that some of the properties will be able to resume.

A contact ore-body was discovered in the Guanacevi district, Durango, last year, and is proving to be of considerable extent, and produces some rich ore. The Desengaño mine produced bullion worth pesos 1,300,000, at a cost of pesos 200,000. One lot of 100 tons yielded about pesos 1000 net per ton. In the Mexico Consolidated and Fortuna, ore has been opened. Operations of the rebels considerably hampered development.

Guanajuato.—The mines of this state have been responsible for a large percentage of the production of the past year.

The Guanajuato Consolidated Mining & Milling Co. reports for the quarter ended June 30 last, as fellows: Total value recovered, pesos 350,246; working expenses including marketing, treatment charges, etc., pesos 269,806; profits, pesos 80,440; expended on development pesos 15,796; balance, pesos 64,643. During the quarter 521 ft. of development work was done. The mill ran a total of 89 days and crushed 22,871 tons of ore. Concentrates shipped aggregated 353 tons. The value of bullion was pesos 184,244, and the value of concentrate pesos 166,002.

The properties in the immediate vicinity of the city of Guanajuato including the Guanajuato Reduction & Mines Co., the Penguico Mining Co., the Humbolt, the Armsted properties, are all in operation. There might also be mentioned in the state the Zaragoza, El Profita, San Carlos, San Antonio, Padre de Dios, the La Luz properties, and many others.

Guerrero.—Mining in this state was of a very desultory character, the Taxco mines showing but little activity, and those in other parts of the state have largely suspended, owing to *Zapatista* activity. A report of the Taxco Mines Co. shows that the company's mines were reopened in August, 1912, after being closed down for about 15 months, in consequence of revolutionary disturbances. The unwatering of the underground working was satisfactorily accomplished, fresh plans were carefully drawn up, and further development on a small scale was continued until May last, when the town of Taxco was again seized by revolutionary forces, and work on the property had to be suspended. Fortunately, it had been left in charge of a reliable foreman, who succeeded in withdrawing the pumps and housing the machinery. In the meantime arrangements

had been made for the manager to go to London to confer with the board as to the future policy of the company, and he arrived in May, 1913. Acting upon the advice of the manager, the directors gave instructions for the sale of the high-grade ore which had been taken out of the mine in the course of development, and the ore thus produced has, since the close of the financial year, realized £6575. The Reforma mine at Campo Morado was examined for the Camp Bird Co.; but, for sundry reasons, one of which was the political unrest, it was dropped.

Hidalgo.—The important producers are of course those of the Pachuca district, all of which have been in continuous operation. These properties include those of the Real del Monte y Pachuca Co., La Blanca Mining & Milling Co., Santa Gertrudis Mining Co., San Rafael y Anexas Mining Co., which is being operated largely on custom ore, San Francisco, and other smaller properties.

The fifth annual meeting of Santa Gertrudis Co. Ltd., was held in London on November 19, and results for the year may be tabulated as follows:

Development, feet	17,000
Ore reserves at June 30, 1913:	
Positive and partly developed, tons	778,000
Probable, tons	269,000
Estimated profit from total reserves	$4,700,000
Ore treated, tons	263,554
Metal recovery:	
Gold, ounces	21,800
Silver, ounces	4,243,000
Net profit, depreciation deducted	$1,110,000
Dividends	1,060,000
Carried forward	38,000

The property is known to contain, besides the main vein, 11 other productive veins, six of which were discovered during the past fiscal year. On No. 16 and 17 levels, west of the San Francisco shaft, an ore-shoot 10 ft. wide and 150 ft. long, with limits undefined, has been opened. Development of No. 19 level was finished, showing a shoot of payable ore nearly 1635 ft. long, although it is narrower and of lower grade than on the level above. Since the end of the year, No. 20 level has been reached and driving started in ore. San Francisco No. 2 shaft is down 1760 ft., and new surface equipment installed, so that it is now convenient to produce 25,000 tons of ore per month, October showing 30,000 tons with a profit of $105,000.

A cable to London on November 23 stated that, on No. 17 level the south cross-cut has passed through 21 ft. of $47 ore per metric ton. The formation is unusual, and it has not been proved whether the shoot is the vein or merely locally mineralized rock.

The San Rafael y Anexas Co. maintained heavy production during the year 1913 and the year's profits are expected to exceed those of 1912, which amounted to $1,617,691. La Blanca y Anexas Co.'s ore production and milling capacity were increased last year by the acquisition of the Cinco Señores mines early in the year, on which the company held an option.

The Real del Monte mines worked without interruption and the monthly tonnage increased from 36,000 to 50,000 tons, while additions to the mills will further increase the output. The ore reserves are reported as being larger than ever, and additional ground is being developed along with the present eight mines of the company.

Jalisco.—This state has produced silver and gold throughout the year, and some important developments have taken place, notably in the Hostotipaquillo district. Here a new mill was erected by the Cinco Minas Co., and another mill has been constructed by the Casados Mining Co. The reduction plant of the former commenced operations on January 15, 1914, and the 30 stamps of the mill are now dropping steadily. It is expected that the mill will reach a capacity of 300 short tons of ore daily within a short time. The machinery for the mill was taken into the camp during the last rainy season, but no delay resulted, and an unusual record in construction was made. The plant is one of the best so far erected in Mexico. There is a big tonnage of milling ore blocked out in the properties and the Cinco Minas Co. will soon rank as one of the most important producers in this part of Mexico.

The additional equipment at the El Favor mill, erected for the use of the Mololoa Mining Co., has been placed in commission. A big tonnage of Mololoa ore will be handled daily. The 20 stamps of the original El Favor mill are now crushing an increased tonnage of El Favor ore, and in addition some custom milling is being done. Ores from nine properties in the Hostotipaquillo district have so far been sent to the El Favor mill, and the company is securing a revenue of $10 on every ton milled. El Favor's acceptance of custom ores is promoting development in the Hostotipaquillo district.

The Amparo Mining Co., operating at Etzatlan, had the most prosperous year in the company's history, the earnings being considerably in excess of those of 1912. The dividend rate has been raised from 4 to 5 per cent. per quarter, and the disbursement to stockholders for the year will amount to $400,000 as compared with $330,000 for the preceding

year. The Magistral-Ameca Copper Co. resumed work at its concentrating plant, and has been shipping concentrate during a great part of the year.

Mexico.—Mining operations in this state have been comparatively normal. The Rincon mine has been operated during the year, shipping 100 tons of high-grade ore per month to the smelter until recently. Twenty stamps are working, producing bullion and concentrate. There, the parent mine, the El Oro Mining & Railway Co., continues productive on a diminishing scale, without any prospect in depth. The Esperanza and the Mexico, the two adjacent mines on the same vein system, have depreciated greatly in value, despite sundry discoveries underground that seemed to postpone the day of exhaustion. The Dos Estrellas, on the other side of the hill, has gone the way of most mines that are boomed on the Paris bourse.

The report of the El Oro Mining & Railway Co. for the year ended June 30, 1913, shows that ore reserves total 448,053 tons, averaging $8.11 per ton in gold, and 3 oz. silver. Ore milled amounted to 253,434 tons, yielding $2,188,724. The profit, including $117,983 from the railway, was $768,000. Dividends were $548,000. The costs totaled $3.44 per ton.

The Mexico Mines of El Oro, during the year ended June 30, 1913, produced gold and silver worth $1,669,540 from 158,395 tons of ore. Costs were $4.12 per ton. Dividends were $769,000, from a profit of $965,000.

The consulting engineers of the Esperanza Mining Co. give the following estimates of the ore reserves on Dec. 31, 1913: 114,000 dry metric tons of ore, which it is estimated will yield a profit of $420,000; and the estimated profit to be derived from the re-treatment of the tailing dump is $240,000, making total estimated profits of $660,000 United States coinage.

The old stope fillings have thus far realized expectations and if they hold out, will materially add to the life of the mine and of the profits. The tonnage of these old fillings is large, and their assay are necessarily erratic, but the grade of old fillings mined during the last quarter has been satisfactory and resulted in a material increase of profits.

Operations at the Dos Estrellas gold mines, in the Tlalpujahua district of Michoacan, for years the most important producer in Mexico, have been reduced to a great extent, and according to advices from Tlalpujahua more than 1200 men have been dispensed with. Reduced value of the ore and increased expenses, including additional taxes and direct contributions as a result of present conditions in Mexico, are given as the reasons for this step. It is understood that considerable exploration work will be

undertaken. For a number of years the Dos Estrellas mines produced approprimately pesos 1,000,000 per month, and half that sum, or pesos 6,000,000 per year, was in dividends.

Oaxaca.—Mining operations of importance have been largely confined to the Taviche district. The San Martin mine has a good tonnage ready for treatment. The San Juan has made a number of shipments and mining operations were conducted almost continuously. Considerable interest has been aroused lately in the Lolita mine, located in the Taviche district. Work has been in progress on the properties for upward of a year and during this time large and rich ore-bodies from 200 to 400 ft. below the outcroppings have been developed and shipments of very high-grade gold and silver ores have been made to the smelters. Forty-six mines are said to be in active operation in the state of Oaxaca, the majority of them being in the districts of Ixtlan, Taviche, and Ejutla. Acitivity is noted also in the Tehuantepec and Yautepec districts.

Sinaloa and Tepic.—These are among the unfortunately situated states, which have been subjected to repeated bandit and so-called revolutionary outrages, with the result that the mining industry is practically at a standstill. The important El Tajo, Panuco, and Guadalupe de los Reyes properties are shut down. The La Dicha Mining & Milling Co. has ordered a 20-ton concentrating plant for the old Dolores property at Ixtlan del Rio in the state of Tepic.

Sonora.—Although this state has been a center for revolutionary activity during the past year, the mines have in large part been in operation. Save for a month or two in the spring of 1913 most of the properties in northern Sonora were working. Those in the southern part of the state, especially along the Yaqui river, have had to suspend operations.

In the north, as well as in some of the central portions of the state, most of the substantial companies have been operating without intermission. However, upon a few occasions some of the companies had to abandon operations for a short time during battles, and bandit raids, as at Nacozari, Cananea, and other points. The great producers are located in the northern portion of the state, and these have been operating steadily, in fact the properties in the northeastern portion of the state have been producing more during the past 6 months than at any other previous time. The Mines Co. of America has been operating steadily at Minas Prietas and La Colorada, but its La Dura property was forced to close down in the fall, after an effort to continue work, but the inability of securing supplies and difficulties without number which faced them almost daily proved too great.

Greene-Cananea, Moctezuma Copper Co., and El Tigre, the three largest concerns in the northern portion of the state, have been operating

continuously all the year, save for short intervals when battles have occurred in their camps. Upon several occasions they were without rail facilities, Cananea being without rail communication for over a month, but, fortunately, all had large supplies on hand which aided in bridging the gap.

Most of the properties south of Cananea are idle, there being a few silver mines operating on a small scale.

Sonora's gold and silver production for 1913 may be estimated as follows:

Ores, 800,000 pesos gold, 2,500,000 pesos silver; concentrate 2,000 pesos gold, 300,000 pesos silver; and bullion 2,800,000 pesos, 25,800,000 pesos, a total of 9,225,000 pesos.

The Lucky Tiger-Combination Gold Mining Co., of Kansas City, Missouri, operating a mine and mill at El Tigre, Sonora, has not been interfered with by the revolution. The stamp-mill has been crushing about 6100 tons of ore, and the cyanide plant treating 7500 tons of tailing per month, while crude ore was shipped to smelters in El Paso. A monthly profit of about $60,000 is being made. Dividends were paid, and bonds retired. Good ore was opened during the year.

The average monthly silver production of the Cananea Consolidated Copper Co. was about 100,000 oz. and about 600 oz. of gold.

While the present conditions in Mexico are very discouraging, there is considerable optimism in the hearts of those who have investments in this country in light of the stand which the American people have taken in regard to Mexico's internal affairs. With peace restored, which now seems likely at no far off time, the mineral industry will resume operations on a scale which has never been equalled in the past and Mexico will again assume her place of prominence in the rank of the mineral producing nations of the earth.

Progress in Gold and Silver Milling During 1913

By C. H. Fulton

The year 1913 presents nothing that is startlingly new in cyanidation and gold and silver milling. On account of the Civil War in Mexico, no progress in cyanidation is reported from there. Comparatively few new mills have been erected throughout the world, the greatest activity being shown in Rhodesia, Africa. Much attention is still being paid to continuous agitation and decantation systems in the hope that filters may be avoided. In fact, many metallurgists seem to advocate a reversion to old methods which have been discarded. This state of mind is probably only temporary and although the filter situation is still far from good,

it is hoped that before long most difficulties will be satisfactorily adjusted. Most of the literature of the year concerns minor improvements in apparatus and methods. The subject of agitation appliances is receiving very serious consideration and a number of new devices have been put on the market. The most promising of these is the Dorr agitator.

Milling Practice

United States.—The Mill of the Gold Road Mines Co.[1] is situated at Gold Road near Kingman, Ariz. This is an old mill which has been frequently remodeled. The method used is to crush in cyanide solution, agitate in a Pachuca tank, and in place of filtration employ counter-current decantation in Dorr thickeners. The ore has a gangue of quartz and calcite, the gold being present in a finely divided free state. The amount of sulphides is small. The ore (360 tons per day) is rough crushed with lime in a No. 5 Gates gyratory crusher which discharges into a 1540-ton bin. Challenge feeders deliver ore to forty 1050-lb. stamps making one hundred four 7 in. drops per minute, and crushing through 4 mesh screens in 2 lb. KCN solution, containing also 2–2.5 lb. CaO per ton, a very high alkalinity. The pulp passes to 2 distributing cones, 4-ft. and 6-ft. diameter respectively which discharge to 6 duplex Dorr classifiers. The sands are reground in four 5×22 ft. tube mills, in closed circuit with the classifiers, the lifting being done by four 10×54 in. Frenier pumps. The slime, 86 per cent. of which passes a 150-mesh screen, goes to two 30×10 ft. Dorr thickeners the overflow solution from which goes to clarifying tanks and presses and thence to zinc dust precipitation system *A*. The thickened pulp, dilution ratio 1:1, passes to three 17×44 ft. Pachuca tanks operated as units for agitation. The agitator discharges its pulp to a series of Dorr thickeners for the counter-current decantation treatment. There are 5 sets of 2 thickeners each for this work. The solution overflow from the first set is pumped to the stock tanks and used as crushing solution. The thickened discharge from this set is diluted with barren solution, and passes to the second set of thickeners, the overflow from which is used to dilute the discharge from the Pachuca tank on its way to the first set of thickeners. The thickened discharge from set number 2 is diluted with barren solution and passes to set number 3. The overflow from this passes to zinc dust precipitation, system *B*, while the thickened pulp is diluted with overflow solution from set number 5 and passes to the fourth set of thickeners. The overflow from this set joins the inflow into set 3, while the thickened pulp is diluted with water and passes to set number 5. The overflow from this set joins the inflow into number 4 as al-

[1] H. A. Megraw, *Eng. Min. Jour.*, XCVI 3.

ready stated, while the thickened pulp is discharged, passing on its way through an automatic sampler. It will be noted that barren solution is the diluting agent in the first two sets of thickeners, while water is used in the last three sets. The Bosqui system of zinc dust precipitation is used. The mill treats low-grade gold ore and the mill solutions are low in metal content. It is an interesting application of the counter-current decantation method[1] replacing Butters filters. Cyanide consumption is 0.4 lb. and lime 0.65 lb. per ton of ore. Zinc consumption is 0.4 lb. per ton of solution precipitated.

The mill of the Tom Reed Gold Mines Co.[2] is situated at Oatman, Arizona, about 1.5 miles distant from the Gold Roads mine, above described. The ore and system of treatment are similar to that at the Gold Road mine, except that a Butters filter is still in use, but will probably be displaced by the counter-current decantation system. The capacity of the mill is 150 tons per day. The mill of the Vulture Mines Co.[3] is situated about 14 miles southwest of Wickenburg in central Arizona. The ore treated is white quartz, containing free gold, and a small amount of pyrite, galena and chalcopyrite. The average value is about $20 per ton. The mill scheme includes amalgamation, concentration and cyanidation by the counter-current decantation system. The accompanying flow sheet, Fig. 1, describes the process.

H. A. Megraw[4] describes the Central Mill of the North Star Mines Co., and the Empire mill, both at Grass Valley, Calif. These mills are very much alike and the latter has been described in some detail in a previous volume.[5] The same author[6] describes the mill of the Black Oak Development Co., at Soulsbyville, Tuolumne County, previously described in the MINERAL INDUSTRY.[7]

A. A. Willoughby[8] briefly describes the new mill of the Globe Consolidated Mining Co. at Dedrick, Calif. This is a 20-stamp all-slime plant, employing a Dorr classifier, one 22×5 ft. tube mill, 4 Dorr thickeners and 3 Dorr agitators and an Oliver 16-ft. filter.

H. A. Megraw[9] describes milling practice at the Liberty Bell Mine, Telluride, Colo., and at the Independence and other mines, Cripple Creek, Colo., already referred to in previous volumes of the MINERAL INDUSTRY[10] S. L. Goodale[11] briefly describes some general features of milling practice at Cripple Creek, Colo.

[1] MINERAL INDUSTRY, XX, 341.
[2] H. A. Megraw, *Eng. Min. Jour.*, XCVI, 199.
[3] H. A Megraw, *Eng. Min. Jour.*, XCVI, 201.
[4] *Eng. Min. Jour.*, XCV, 983.
[5] MINERAL INDUSTRY, XXI, 387.
[6] *Eng. Min. Jour.*, XCV, 1179.
[7] MINERAL INDUSTRY, XXI, 389 and *Met. Chem. Eng.*, XI, 640.
[8] *Eng. Min. Jour.*, XCVI, 688.
[9] *Eng. Min. Jour.*, XCV, 3, 313.
[10] MINERAL INDUSTRY, XX, 327 and 325.
[11] *Min. Sci. Pr.*, CVII, 297.

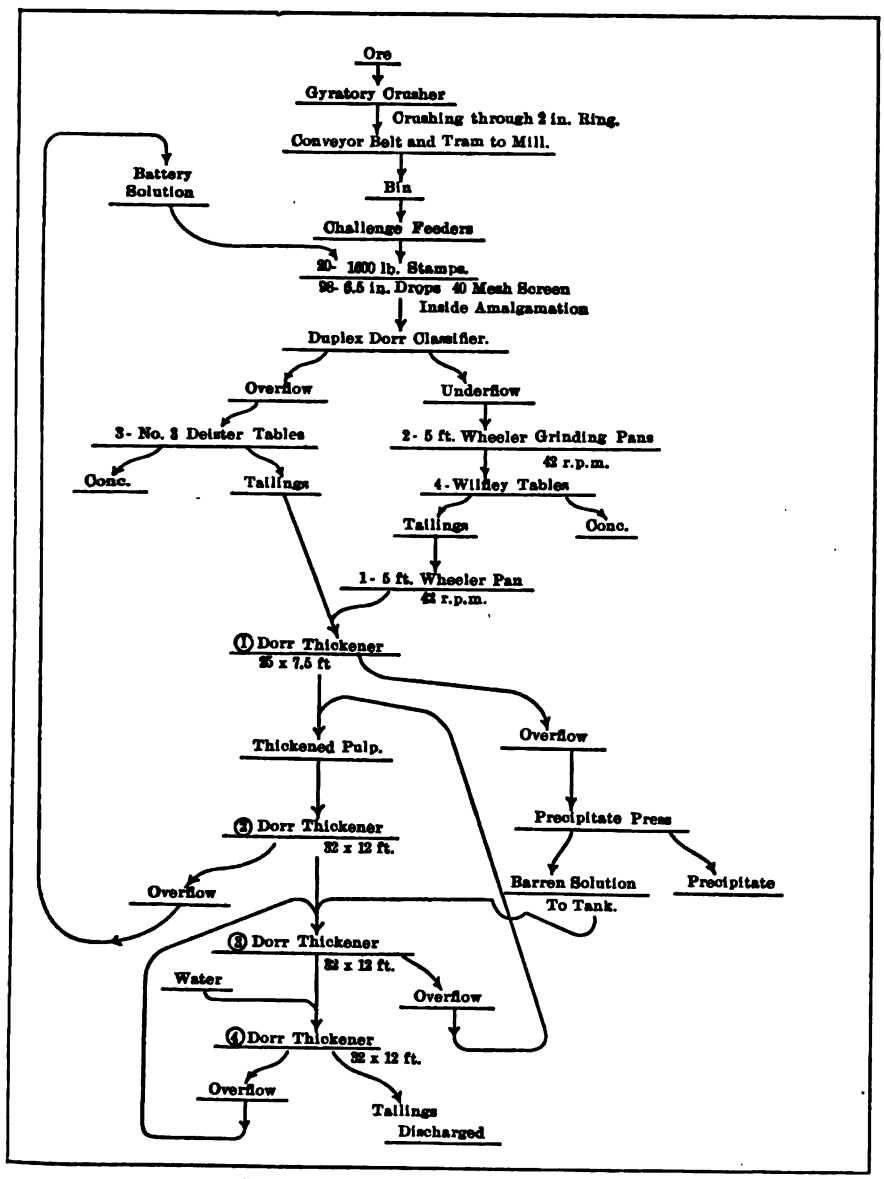


FIG. 1.—Flow sheet of the Vulture Mines Co.

The New Argo Mill, at the mouth of the New House tunnel, Idaho Springs, Colorado, is described by S. L. Goodale.[1] This is a custom mill for the treatment of the complex ores of this district. It employs crushing in cyanide solution, amalgamation, concentration on card tables, making a lead, iron and a copper concentrate, air agitation, and counter-current decantation in Dorr thickeners. The mill has a capacity of about 135 tons per day. J. C. Kennedy[2] describes in some detail the mill of the

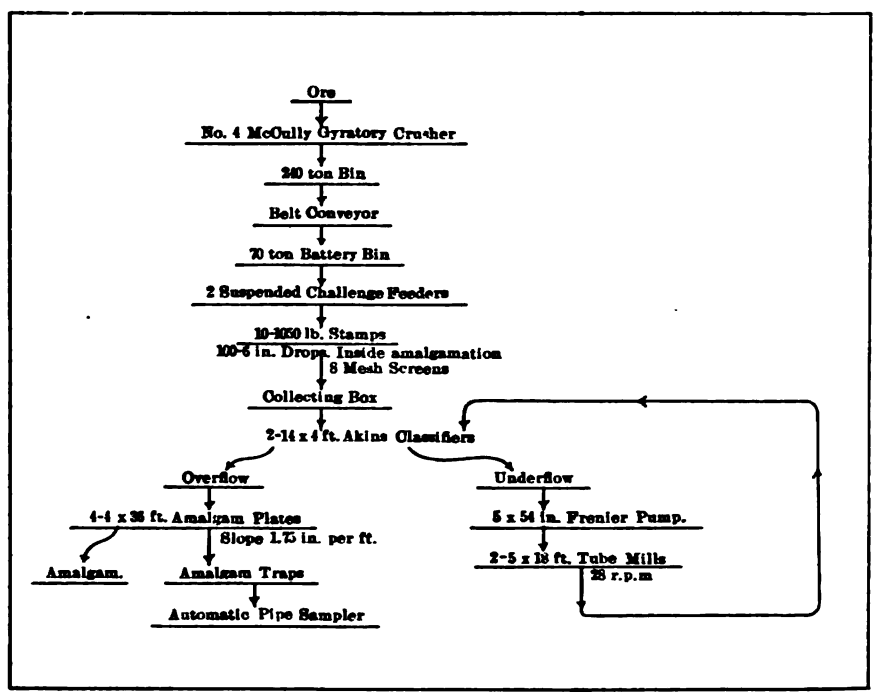


FIG. 2.—Flow sheet of Big Four Manhattan Mining Co.

Manhattan Ore Milling Co. at Manhattan, Nev., described in a previous volume of the MINERAL INDUSTRY. H. A. Megraw[3] describes with much interesting detail, the practice at the Nevada Hills mill at Fairview, and that at the Nevada Wonder Mill at Wonder, Nev. These mills have been described in the MINERAL INDUSTRY.[4] The new mill of the Big Four Manhattan Mining Co., at Manhattan, Nev., treats an ore which is a soft brown colored calcareous schist containing fine gold which occurs generally along the laminations of the schist and in innumerable small cross fractures. These fractures are filled with calcite which is sometimes replaced

[1] *Eng. Min. Jour.*, XCVI, 385, 1036.
[2] *Min. Eng. World*, XXXVIII, 859; MINERAL INDUSTRY, XXI, 386.
[3] *Eng. Min. Jour.*, XCV, 645, 693.
[4] MINERAL INDUSTRY XX, 372, 373.

by quartz. Sulphides are practically absent. The mill has a capacity of about 100 tons per day, and is interesting from the fact that only amalgamation is used. The plate area is very large and in this respect it resembles Homestake practice. Fig. 2 gives the flow sheet of the mill.

A 75-ton tailings plant has been constructed at the Quartette mine[1] at Searchlight, Nevada. The tailings which contain $5.00 in gold and 0.75 per cent. copper are charged into an Akins mixer with 6 parts cyanide solution, and with 3 lb. lime per ton tailings. The pulp is then classified into 40 per cent. sand and 60 per cent. slime in an Akins classifier, each product being treated in the usual manner. In the slime treatment an Akins agitator and a Portland filter are used. The cyanide consumption is 2.75 lb. per ton. M. W. von Bernewitz[2] describes the McNamara mill at Tonopah. This mill crushes about 70 tons per day of hard Tonopah 20 oz. silver ore, with ten 1400-lb. stamps, making ninety-eight 8 in. drops per minute. Number 12 ton-cap slotted screens are used, and crushing is done in cyanide solution. The mill uses a Dorr classifier, a 5 × 16 ft. tube mill, a Frenier pump, one 12 × 26 ft. Dorr thickener, three 15.5 × 25.5 Trent agitators, storage tanks and a 50-leaf vacuum filter. The cost of milling is given as $3.30 per ton. H. A. Megraw[3] describes and discusses the milling practice of the Tonopah district with much detail. The following mills are described: the West End, Montana-Tonopah, Tonopah Extension, McNamara, at Tonopah and the Tonopah Belmont and the Desert mill at Millers, Nevada. The new Belmont mill at Tonopah has not as yet been described. Jay A. Carpenter[4] describes details of practice and gives costs at the West End mill, Tonopah. Jesse Simmons[5] describes briefly the equipment of the new mill of the Mogul Min. Co. at Terry, S. D., which replaces the one at Pluma recently destroyed by fire. The mill will be a sand-and-slime treatment plant, using gyratory crushers, rolls and Chilean mills for crushing. The slimes will be treated by counter-current decantation in Dorr thickeners; no filter is to be used. Other South Dakota mills, Wasp No. 2; Golden Reward, Deadwood; Trojan; Bismark; Reliance; Lundberg, Dorr and Wilson, are again described.[6]

The practice at the Reliance Mill situated at Trojan, S. D., is as follows: The mill feed consists of oxidized and partially oxidized Cambrian ore and is crushed in a gyratory crusher, and thirty 1000 lb. stamps. These crush in solution, 4 to 4.5 tons per ton of ore, through a 0.023-in. slotted screen, and have a capacity of 3½ tons per stamp. The pulp is passed to a Dorr classifier, the overflow from which is 60 per cent. of

[1] *Min. Sci. Pr.*, XCVI, 953.
[2] *Min. Sci, Pr.*, XCVI, 182.
[3] *Eng. Min. Jour.*, XCV, 413, 455, 503, 534, 767, 912, 1110.
[4] *Min. Sci. Pr.*, CVII, 191.
[5] *Eng. Min. Jour.*, XCVI, 489.
[6] H. C. Parmelee, *Met. Chem. Eng.*, XI, 395, 435 and 500.
Jesse Simmons, *Min. Eng. World*, XXXVIII, 11, 1051.

the total, while the underflow or sand is 40 per cent. Ninety-seven per cent. of the sand remains on a 200-mesh screen, and 80 per cent. of the slime passes a 200-mesh screen. The sand is leached in the usual manner in five 100-ton vats. The slime is treated by counter-current decantation and filtration with a Portland filter. The thin slime pulp from the classifier flows to a 20-ft. cone and then through four Dorr thickeners in the manner shown in Fig. 3.

The *washed* slime pulp entering the thickeners has a value of $1 to $1.50 per ton, and that discharged from the fourth thickener has a value of 40 to 80 cents per ton. The difference is the amount of solution which takes place in the thickeners. The value of the pulp (including gold in

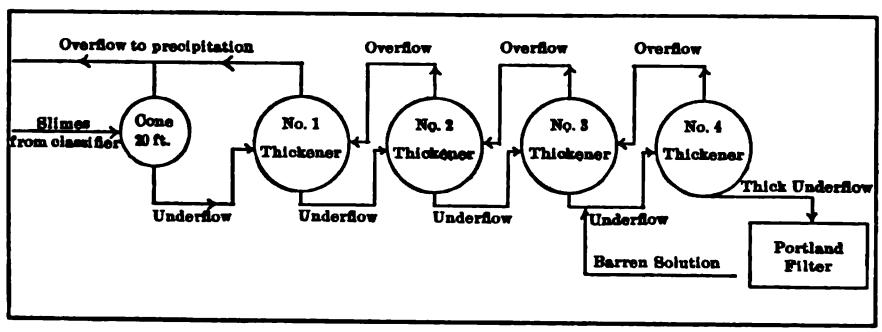


FIG. 3.—Slimes flow sheet, Reliance Mill.

solution) passing to the filter is from $1.40 to $1.60 per ton, the value of the gold solution in the mill is from $1.20 to $1.80 per ton. The loss in dissolved gold is 5 to 12 cents and the mechanical loss of cyanide is 0.5 lb. per ton dry slime. While this process is stated to be the counter-current decantation system it is evident that since no agitation devices are employed to dissolve gold previous to the use of the thickeners, that it is not a typical application of this system. The cost of milling is given as $1.234 per ton.

H. A. Megraw[1] describes the new mill of the North Washington Power and Reduction Co. and that of the San Poil Cons. Co., both near Republic, Wash. Many attempts have been made to treat the ores of this district, but not until these mills were constructed was success attained. At the North Washington mill the ore is a close textured blue quartz, with some softer white quartz, that contains very finely divided gold, and silver probably present as the sulphide. Some copper and selenium compounds are present. The average value of ore recently milled was $9.50 per ton. An idea of the relative value of the silver

[1] *Eng. Min. Jour.*, XCV, 835.

and gold may be obtained from assays on ore from the Surprise Mine which contained, gold 0.51 oz.; silver 5.80 oz.; copper 0.2 per cent. The method of milling is outlined in the accompanying flow sheet, Fig. 4. The capacity of the mill is about 100 tons per day. The mill scheme of the San Poil Mill is similar, except that it uses a Williams' hammer trommel mill to crush ore from mine size down to 0.1875 in. feed for the rolls, and employs tube mills directly after rolls, Dorr classifiers, Dorr thickener, air agitation tanks (modified Pachuca type) and zinc thread precipitation.

Claud Hafer[1] describes the small mill of the Candor Mines Co. situated in Montgomery County, North Carolina. The ore is gold quartz and 50 tons daily are crushed by a 9 × 15 in. Blake crusher and five 1750-lb. stamps. The stamp screen is 0.25-in. mesh. Crushing is done in cyanide solution. The pulp passes to a Dorr classifier, the underflow from which goes to a 4 × 20 ft. tube mill which returns its product to the classifier by a Frenier pump. The slime overflow is thickened in an 18 × 8 ft. Dorr thickener and then passes to 3 Parral vats (18 × 29 ft.) in series for agitation. The filter used is a Kelly pressure filter No. B. Zinc thread precipitation is used. The extraction is 95.5 per cent. and the cost of milling is $1.64.

Canada.—The new McIntyre-Porcupine mill is described in the annual report of the Company.[2] This 150-ton mill is situated near Porcupine, Ont. The gold ore is crushed in a 10 × 12 in. Blake crusher and a 16 × 36 in. set of rolls, and then passes to a 500-ton storage bin. The fine crushing is done in cyanide solution by a 6-ft. Chilean mill—4 tons of 1.25 lb. KCN solution per ton of ore being used. A 6-mesh screen is used. The pulp passes to a Colbath classifier, the underflow from which (material + 100 mesh) passes to a tube mill and second classifier in closed circuit with the Colbath classifier, the lifting being done by a Frenier pump. The classifier overflow passes to a 16 × 24 ft. thickener. The overflow from this passes to a 12 × 20 ft. clarifying tank and thence to zinc shaving precipitation. The thickened pulp is diluted with solution and passes to a 16 × 24 ft. agitator operated continuously and which discharges to a 20 × 24 ft. thickener. The thickened pulp is filtered by a Burt filter.

C. Earl Rodgers[3] describes the mill of the Motherlode Sheep Creek Mining Co., 12 miles from Salmo, British Columbia. The ore is crushed by a 10 × 12 in. Blake crusher (1 in. ring) and ten 1250-lb. stamps in water. With a 14-mesh screen (0.046 in. aperture) the capacity is 70 tons per day. The stamps make ninety-six 7.5 in. drops per minute. The pulp passes to a Dorr duplex classifier the underflow from which is

[1] *Min. Sci. Pr.*, CVI, 728. [2] *Min. Sci. Pr.*, CVII, 52. [3] *Eng. Min. Jour.*, XCVI, 529.

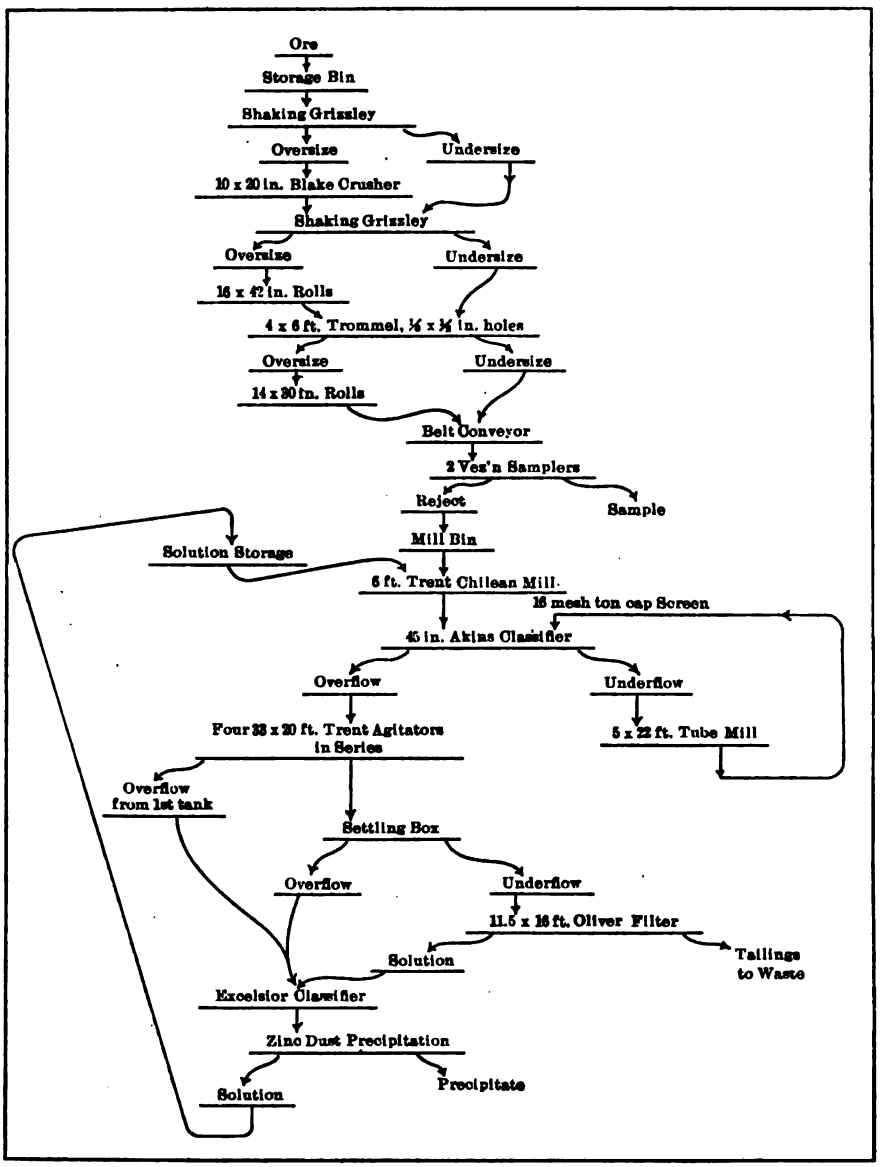


FIG. 4.—Flow sheet of North Washington Power and Reduction Co.

reground in a 5 × 20 ft. tube mill; the tube mill product passes over 2 amalgamating plates in parallel, one 6 × 17, the other 6 × 12 ft. The grade of the plates is 2.375 in. per foot. From these plates the pulp is returned to the classifier by two 10 × 54 in. Frenier pumps. The overflow from the classifier passes to a 10 × 30 ft. Dorr thickener the overflow from which is used as battery water while the underflow, sp. gr. about 2, is sampled automatically, diluted with barren solution and transferred by two 5 × 5 in. Aldrich slime pumps to four 8 × 25 ft. Pachuca tanks arranged in series for continuous agitation. These tanks discharge by the slotted sleeve arrangement to a 25 × 10 ft. Dorr thickener, the overflow from which passes to a storage tank and thence through a Merrill 12 frame 3 × 3 ft. clarifying press to the Merrill zinc dust precipitation system. The thickened pulp from the Dorr thickener passes to a 25 × 10 ft. sludge tank with mechanical agitators, 6.5 r.p.m., and from here, at a gravity of 1.6 to 1.7 to two 35 frame (34 × 4 ft.) Merrill slime presses. The slime is very granular in character. The effluent solutions from the presses pass to the zinc dust precipitation. The precipitate is acid treated, fluxed and melted in gasoline fired furnaces.

Mexico.—J. P. Holcombe[1] describes the San Francisco mill at Pachuca, Mex. The ore comes from several mines and dumps and contains silver chiefly in the form of sulphide. A little galena, blende and pyrite are present as well as some manganese minerals. The ore contains about 19 oz. Ag and 0.10 oz. Au per metric ton. The flow sheet of the mill is given in Fig. 5. The strength of solution in the Pachuca tanks is 0.4 per cent. KCN, as sodium cyanide, and 2 lb. CaO. Lead acetate is used to the extent of 0.66 lb. per ton ore. Cyanide consumption is 1.83 lb. per ton ore. The filter cycle is 86 minutes.

H. A. and R. T. Sill[2] describe the cyaniding of low-grade silver ore at the Zambona mill, in Minas Nuevas, Sonora, Mex. 150 tons of silver ore of the following composition are treated daily: SiO_2, 62.51 per cent.; Al_2O_3, 11.39; Fe_2O_3, 5.68; CaO, 6.22; Cu, 0.33; Zn, 0.58; CO_2, 2.54; K_2O, 6.56; Na_2O, 1.41; MgO, 0.64; SO_3, 0.02; 60 per cent. of the silver is present as argentite and 40 per cent. as chloride. The ore is crushed in an 8 × 10 Blake crusher and twenty 1050-lb. stamps crushing in 1.3 to 1.8 lb. cyanide solution, through 12-mesh screens. The pulp flows to a 5-ft. settling cone, the sand from which is ground in an 8-ft. Hardinge tube mill, the product from which joins the overflow which goes to 2 Dorr classifiers. The classifier overflow passes to two 16-ft. Dorr thickeners, while the underflow goes to a 4.5 × 16 ft. Allis-Chalmers tube mill, the product from which is returned to the classifiers by Frenier pumps. The tube mills use native quartz. The thickened pulp from the

[1] *Trans. Inst. Min. Met. Bull.*, 103 and 104; *Eng. Min. Jour.*, XCV, 1104.
[2] *Eng. Min. Jour.*, XCV, 745, 962.

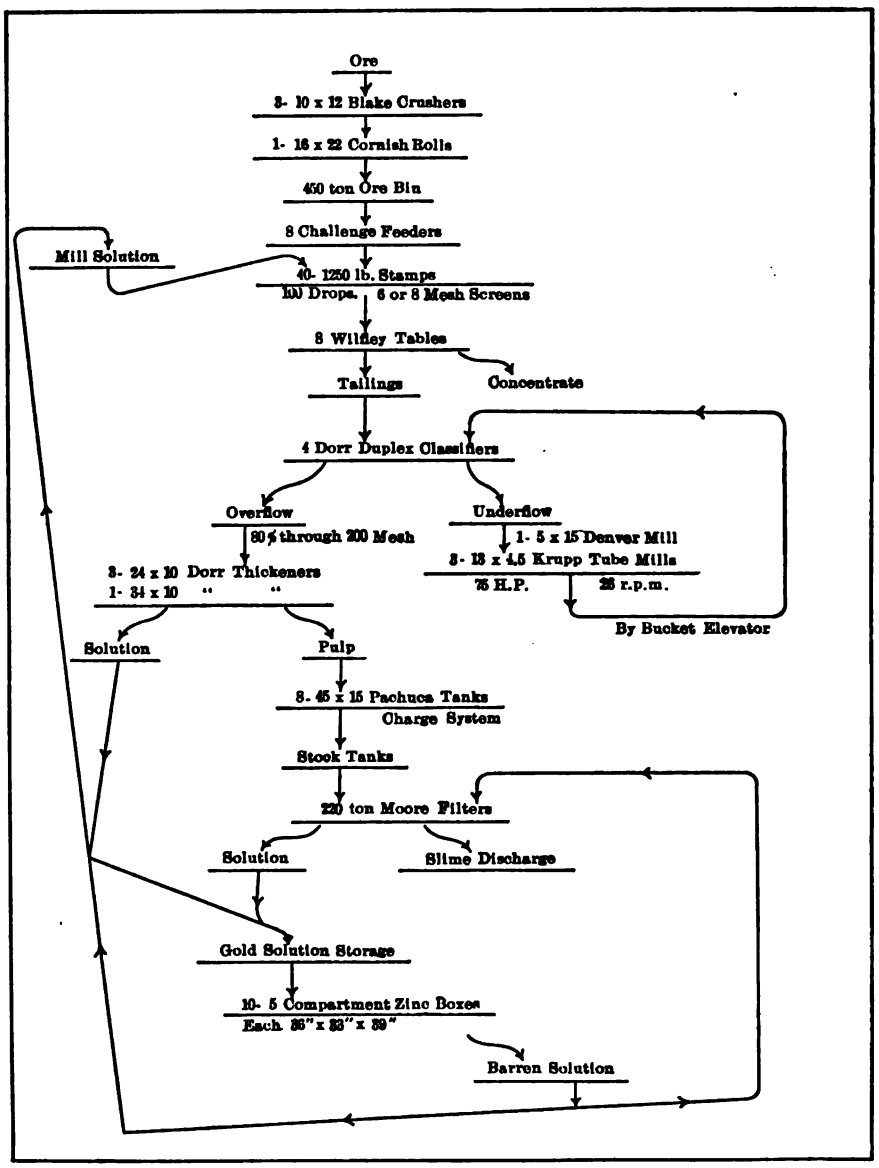


FIG. 5.—Flow sheet of San Francisco mill.

Dorr thickeners goes to a stone storage tank provided with an agitation device, and then to three 50 × 12 ft. Pachuca tanks, operated on the charge system. The overflow from the thickeners is used as battery solution being mixed for this purpose with barren solution. From the Pachuca tanks the pulp passes to two Oliver filters, the solution from which passes to zinc dust precipitation. The extraction in the mill is divided as follows: 50 per cent. in stamps and tube mills, 15 per cent. in Dorr thickeners and 14 per cent. in Pachuca tanks. An ingenious zinc dust feeder is described. Solutions from the precipitation press are tested by means of sodium sulphide solution. A white precipitate indicates excess zinc dust, a brown coloration unprecipitated silver. It is aimed to have a slight brown tinge in the test in order to produce precipitate of the highest grade. The cost of milling is $1.78 per ton.

H. F. Carter[1] describes the 250-ton mill of Cia Beneficiadora de Pozos at Pozos, Guanajuato, Mex. The mill employs the following machinery: Symons gyratory crushers; Symons disc crushers for reduction to 0.5 in.; 6 Chilean mills, low speed, large runners; Dorr classifiers; Krupp tube mills; Deister sand concentrators for tube-mill product; Dorr thickeners; Frenier pumps; 6 Pachuca tanks in series and Moore filter. An anonymous author[2] describes the Tajo mill near San Sebastian, Jalisco, Mexico. The ore is about 90 per cent. quartz, 5 per cent. clay and 1 to 5 per cent. sulphides, pyrite, galena, blende, argentite, and chalcopyrite, named in the order of amount present. The ore is crushed in Blake crushers and light stamps in cyanide solution, and the pulp concentrated on Wilfley tables and then classified in a Dorr classifier. The sands are reground in tube mills and again concentrated and the pulp returned to the classifiers. The overflow from this passes to a collecting tank and then to air agitation tanks of special design, on the charge or unit system. A locally designed filter will be replaced by Dorr thickeners and an Oliver filter.

Africa.—Owen Letcher[3] describes new treatment plants in Rhodesia. There are at the present time either ordered, in course of construction or just completed, 7 different reduction plants with a combined capacity of about 1,068,400 tons per year. The list is as follows:

Mine.	Locality.	Type of Plant.	Annual Capacity.
Shamva	Aercorn, Mashonaland	Nissen stamps	550,000
Cam & Motor	Gatoona, Mashonaland	Ball Mills, Roasters, tube mill, slime plant.	180,000
Falcon	Blinkwater, Mashonaland	Nissen stamps, conc. plant. Blast-furnace and converters	180,000
Antelope	Southwest Mataeland	Ball mills, roasters, grinding pans	48,000
Bell	Jue Jue	Stamps, roasters and slime plant	48,000
Kimberly Reef	Masoe, Mashonaland	Nissen stamps, tube mill, sand and slime plant	36,000
New Found Out	Gadsema, Mashonaland	Similar to Cam and Motor	26,400

[1] *Mex. Min. Jour.*, XVI, 285. [2] *Mex. Min. Jour.*, XVI, 137.
[3] *Min. Sci. Pr.*, CVII, 761, 381; CVI, 509; *Min. Mag.*, VIII, 224; *Met. Chem. Eng.* XI, 291.

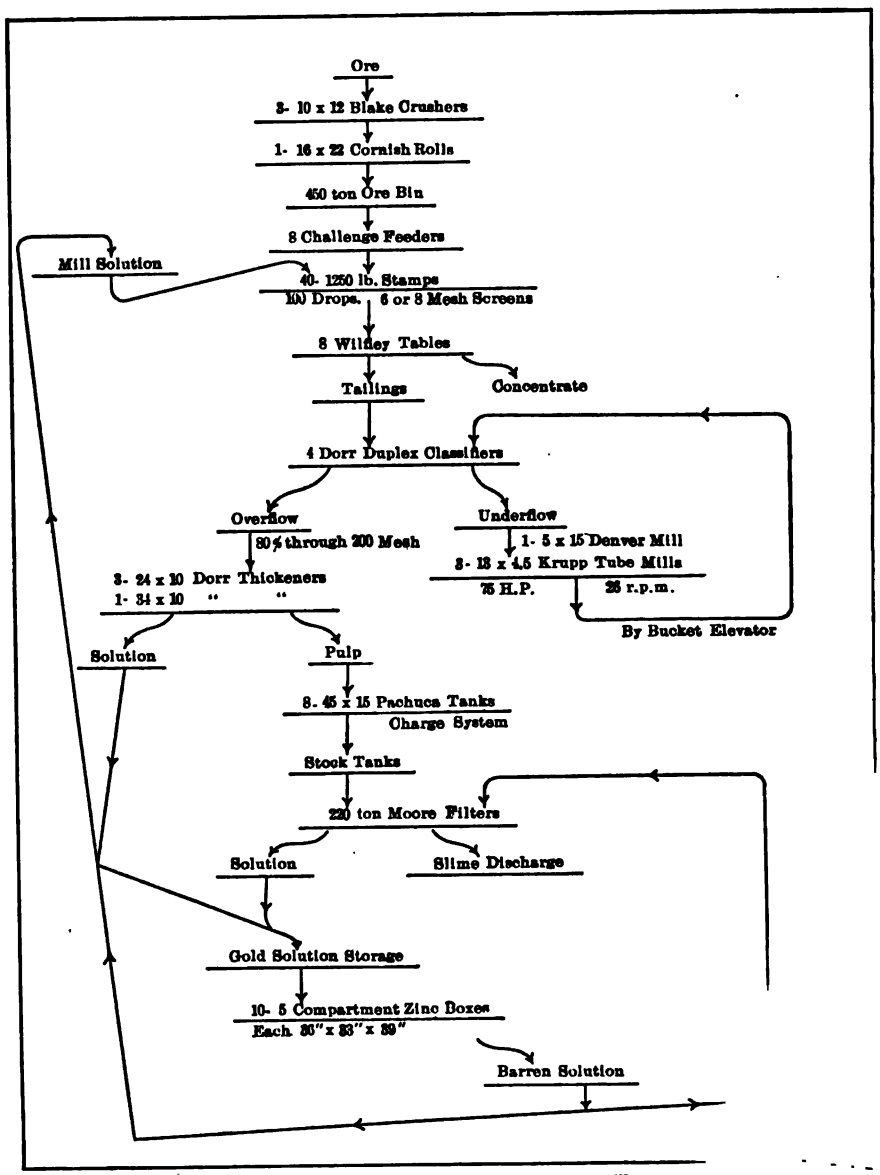


FIG. 5.—Flow sheet of San Francisco mill.

Dorr thickeners goes to a stone storage tank provided with an agitator device, and then to three 50 × 12 ft. Pachuca tanks, operated on the charge system. The overflow from the thickeners is used as wash solution being mixed for this purpose with barren solution. From the Pachuca tanks the pulp passes to two Oliver filters, the solution from which passes to zinc dust precipitation. The extraction in the mill is divided as follows: 50 per cent. in stamps and tube-mills, 15 per cent. in Dorr thickeners and 14 per cent. in Pachuca tanks. An ingenious zinc dust feeder is described. Solutions from the precipitation press are tested by means of sodium sulphide solution. A white precipitate indicates excess zinc dust, a brown coloration unprecipitated gold, the latter is aimed to have a slight brown tinge in the test in order to obtain a precipitate of the highest grade. The cost of milling is $1.

H. F. Carter[1] describes the 250-ton mill of the Beneficiadora at Pozos, Guanajuato, Mex. The mill employs the following machinery: Symons gyratory crushers; Symons disc crushers for reduction; 6 Chilean mills, low speed, large runners; Dorr classifiers; Deister sand concentrators for tube-mill product; Frenier pumps; 6 Pachuca tanks in series and Moore filters. The latter will consist of three 12 × 30 sulphides, pyrite, galena, blende, argentite and chalcopyrite, in the order of amount present. The ore is crushed in Blake stamps in cyanide solution, and the pulp concentrates on and then classified in a Dorr classifier. The sands are ground in tube-mills and again concentrated and the pulp returned to the overflow from this passes to a collecting tank and is pumped to tanks of special design, on the charge or unit system. The filter will be replaced by Dorr thickeners and a

Africa.—Owen Letcher[2] describes new treatment plants. There are at the present time either ordered or just completed, 7 different reduction plants with a total capacity of about 1,068,400 tons per year. The list is as follows:

Mine.	Locality.
Shamva	Abercorn, Mashonaland
Cam & Motor	Gatooma, Mashonaland
Falcon	Blinkwater, Mashonaland
Antelope	Southwest Matabeleland
Bell	Jue Jue,
Kimberly Reef	Masoe, Mashonaland
New Found Out	Gadzama, Mashonaland

[1] *Mex. Min. Jour.*, X
[2] *Min. Sci. Pr.*, CV

n India.[2] ining Co. The first , it will con- e to crush in dewatering, ree 12 × 30 oxes for pre- ne milling at the ntly constructed oldfield of West rushed in a No. 5 pulp is classified in × 16 ft. tube mill, nate the coarse gold, tailings wheel. The es thickeners and then solution from these is s to 4 agitation vats and filters, each with 800-ft. neans of zinc thread. orious mine at Ora Banda, value of from $4.50 to 6.25

Sci. Pr., CVII, 978.
Sci. Pr., CVII, 217
Mag., VIII, 373.

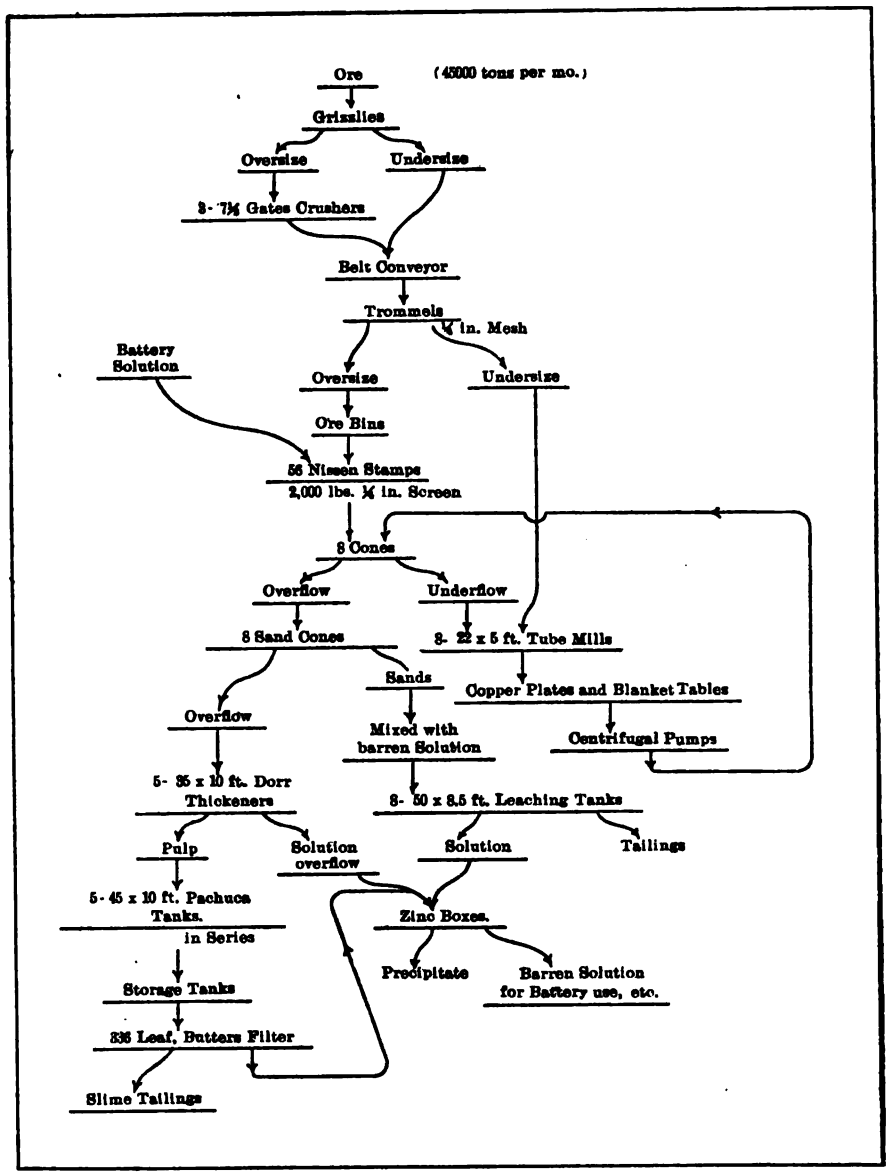


FIG. 6.—Flow sheet of Shamva mill.

The largest of these plants is the Shamva mill at Abercorn, Mashonaland, controlled by the Goldfields Rhodesian Development Co. This mill is now practically completed. The accompanying Fig. 6 gives the flow sheet. G. F. Dickson[1] describes the new mill of the Cam and Motor property situated at the Eiffel Flats near Gatoona, Mashonaland. The typical ore is a grayish-green compact rock containing quartz and calcite, iron and arsenical pyrite and some stibnite and graphite. The following mineral analysis gives the principal constituents: Quartz and silica, 44.33 per cent.; iron pyrite, 2.95; mispickel, 2.15; stibnite, 0.15; calcium carbonate, 14.10; magnesium carbonate, 26.10; graphite, traces. Efforts to treat the ore in the raw state showed the necessity of adopting roasting, and in general the scheme of treatment is similar to that of the Golden Cycle mill, at Colorado Springs. The flow sheet of the mill is shown in Fig. 7.

Asia.—H. M. Leslie describes in detail cyanide practice in India.[2] J. D. Hubbard[3] describes the reduction plant of the Chosen Mining Co. in the North Pyeng An Province, Yeng Byen district, Korea. The first unit now under construction is to have a capacity of 200 tons; it will contain a 4K gyratory crusher, twenty 1250-lb. stamps, which are to crush in solution, 2 duplex Dorr classifiers, a Trent agitator for dewatering, two 5 × 22 ft. tube mills, 5 × 12 ft. amalgam plates, three 12 × 30 ft. Trent agitators, an 80-leaf Butters filter, and zinc boxes for precipitation.

Australia.—An anonymous[4] article briefly describes the milling at the Crown mine, Karangahake, New Zealand. The recently constructed mill of the Bullfinch Proprietary[5] in the Yilgarn goldfield of West Australia has a capacity of 200 tons. The ore is crushed in a No. 5 Symons crusher and fifteen 1250-lb. stamps. The pulp is classified in cones, the underflow from which is reground in a 4 × 16 ft. tube mill, and then passes to an 8-ft. grinding pan to amalgamate the coarse gold, after which it is returned to the classifiers by a tailings wheel. The classifier overflow passes to two 8 × 25 ft. Forbes thickeners and then to two 6 × 25 ft. settling tanks. The overflow solution from these is returned for battery use. The thick pulp passes to 4 agitation vats and after agitation is filtered in 3 No. 3 Ridgeway filters, each with 800-ft. filtering area. Solutions are precipitated by means of zinc thread.

C. M. Harris[6] describes the mill of the Victorious mine at Ora Banda, West Australia. The gold ore treated has a value of from $4.50 to 6.25

[1] *Min. Mag.*, IX, 132; VIII, 121.
[2] *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 634.
[3] *Min. Sci. Pr.*, CVI, 510.
[4] *Min. Sci. Pr.*, CVII, 978.
[5] *Min. Sci. Pr.*, CVII, 217
[6] *Min. Mag.*, VIII, 373.

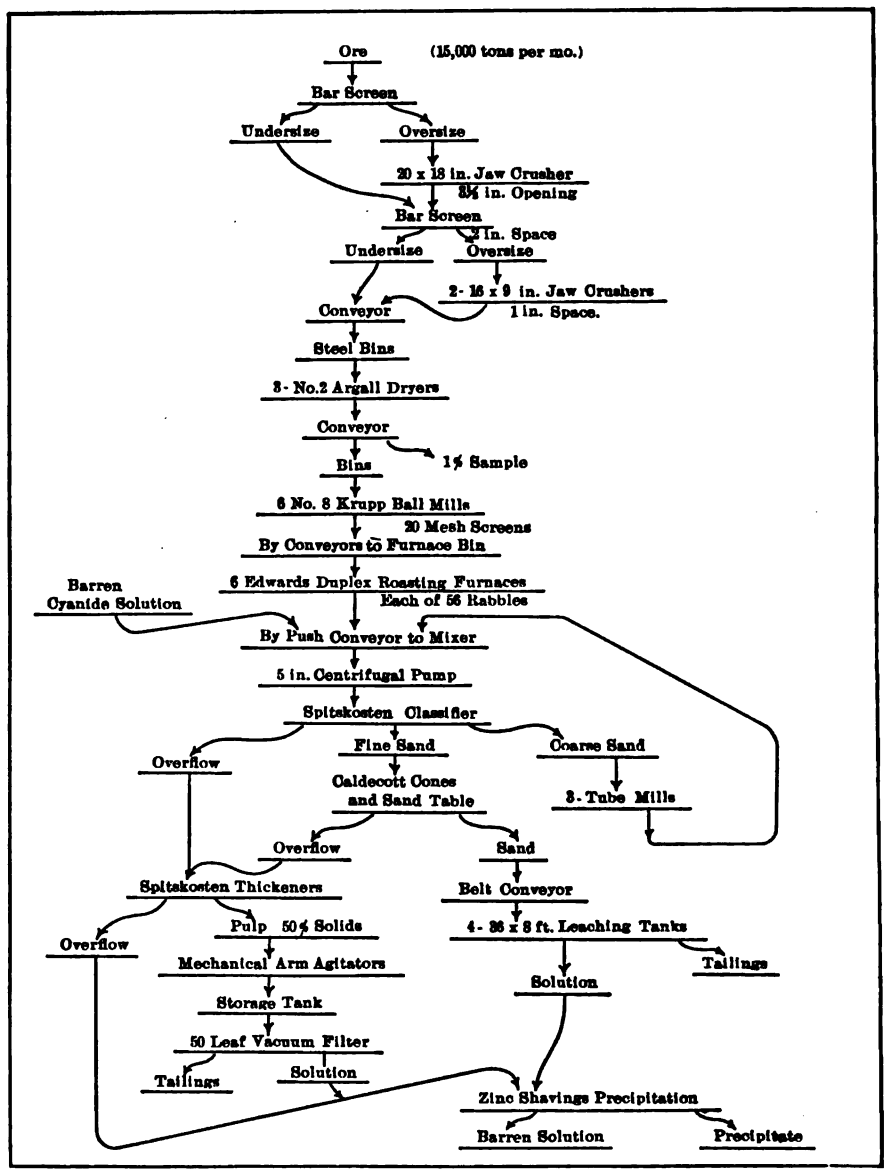


FIG. 7.—Flow sheet of Cam and Motor mill.

per ton. It is crushed in an 18×10-in. Blake crusher and in 5×5 ft. Huntington mills in cyanide solution. The pulp after passing over amalgam plates is classified, the sand being ground in Wheeler pans, the coarse gold at the same time being amalgamated. The pulp from the pans joins the classifier overflow and passes to 4 thickeners, the overflow solution from which is used in the Huntington mills. The thickened pulp goes to three 20 ×6-ft. agitators and after agitation to 3 Ridgeway filters. W. A. MacLeod[1] discusses metallurgical tendencies in Western Australia and briefly reviews methods of operation at some of the newer Western Australian plants. James Hutton[2] describes the cyaniding of gold-silver ore at the Caveira mine, Portugal.

The Treatment of Slime

General.—The question of continuous counter-current decantation, and of continuous agitation as against intermittent agitation is still receiving much attention from metallurgists. While the question of decantation and agitation are two distinct subjects they sometimes become mixed in the discussions, and it is proposed in some instances to make the agitator and the decanting device one and the same apparatus. The prominence of counter-current decantation is due to two causes, the recent filter litigation, and the question of filter royalties and the success of the Dorr thickener as a continuous decanting device. The ability of the Dorr apparatus to discharge a really thickened product and to operate continuously makes it immeasurably superior over the old form of decantation apparatus, but it must be borne in mind that the decantation principles applied are still the same, and when strong cyanide solutions and solutions of high value must be dealt with, the number of decantations required is so great as to make the plant cumbersome and the cost of operation greater than filtering. In the old intermittent decantation system, solution of the metals frequently went hand in hand with the decantation operations, with the result that it was not possible to take full advantage of the dilution effect of added solution for removing gold and cyanide. With the introduction of filters it became apparent that solution must be effected by agitation in separate apparatus. This is also true for decantation, *i.e.*, when decantation is applied to pulp, the gold or silver should be in the pulp in dissolved form. This principle can be neglected only when ores are treated in which the metals are very readily soluble or when very low-grade ore is milled. H. St. J. Brooks[3] discusses continuous decantation *vs.* filtration. He considers continuous decan-

[1] *Min. Sci. Pr.*, CVII, 424.
[2] *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 312, 421, 540.
[3] *Min. Sci. Pr.*, CVI, 608, 624; see also H. A. Megraw, *Eng. Min. Jour.*, XCV, 627.

tation inapplicable to ores in which the greater part of the gold and silver is locked up in sulphides, or to high-grade ores that require extra strong solutions. He would apply the system to low-grade siliceous ores requir-

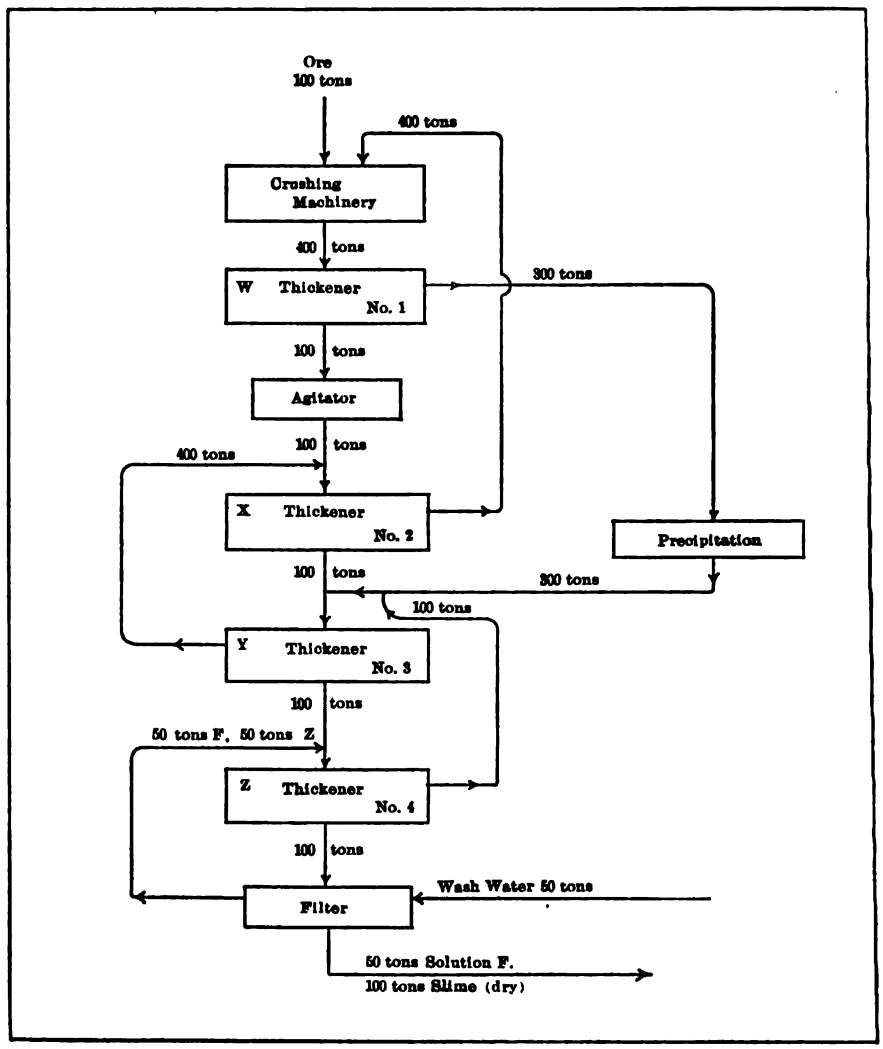


FIG. 8.—Counter current decantation.

ing solutions of only moderate strength, and even in this case prefers to combine filtration by rotary filters with the decantation. While the Dorr thickener can discharge pulp with but 40 per cent. moisture, it is questionable whether it is desirable to have it contain less than 50 per cent. in the

continuous decantation system operated on gravity basis on account of the difficulty of getting a thorough mixture of the thickened pulp with solution in forming the inflow for the next thickener in line. A typical system of continuous counter-current decantation as advocated by the Dorr Cyanide Machinery Co. is described by Jesse Simmons.[1] Fig. 8 gives the flow sheet. The assumptions made are as follows: 100 tons of ore crushed, from which $4 of metal is dissolved per ton. Seventy-five per cent. of the solution takes place in the crushing machinery, etc., and 25 per cent. in the agitator. Pulp from the thickeners contains 1 of solution to 1 of solids. Barren solution has a value of 2 cents. Washing efficiency of filter is 75 per cent., and discharged tailings contain 33.3 per cent. moisture. The letters W, X, Y, Z and F, represent the value of the solutions in the several thickeners and filter. By calculation it can be determined that the value of these solutions is as follows: W = $1.3474; X = 0.59741; Y = 0.15991; Z = 0.14214 and F = 0.03553.

H. C. Parmelee[2] describes in detail the mill of the Ophir Gold Mines, Milling and Power Co., at Ophir, San Juan district, Colorado. This mill employs the counter-current decantation system without filtration, treating ore containing $8 to $12 in gold and consisting of quartz and clay. The mill uses stamps, Hardinge mill, Dorr classifier, Dorr agitators and Dorr thickeners. The flow sheet is very similar to that given in Fig. 8, except that two Dorr agitators are used in series, and an extra thickener replaces the filter.

Agitation.—C. F. Spaulding[3] describes a system of agitation of pulp by means of solution. His system consists of employing an agitation tank about 20×20 ft. flat bottom, containing a central open cylinder 10×10 ft. provided with baffles, the top of which is above the level of the pulp in the tank, and which acts as an inner settling vat. Four 10-in. pipes open at the bottom and fitted with an L at the top rise 6 in. above the level of the pulp. Into these discharge at the bottom, 1-in. pipes carrying barren solution causing them to act as transfer pipes, in the manner of the Parral agitator,[4] except that this uses air. The pulp flows into the vat at some point near the circumference, is agitated by means of the lift pipe, with continuous addition of fresh barren solution, while nearly clear solution is decanted from the central settling cylinder. This solutions passes through a settling tank or press for clarification if necessary, then to zinc precipitation and is returned by centrifugal pump to the tank for agitation purposes. Three such sets may be combined in a mill, pulp flowing from one agitation tank into the other continuously, the pulp from the last going to a settling tank, the overflow from which is re-

[1] *Eng. Min. Jour.*, XCV, 627.
[2] *Met. Chem. Eng.*, XI, 25.
[3] *Min. Sci. Pr.*, CVI, 342, 334, 950.
[4] MINERAL INDUSTRY, XXI, 407.

turned to the head of the mill for crushing purposes. In treating ores that settle with difficulty, it is suggested that vacuum filter leaves, according to G. J. Young, be immersed in the agitation tank to draw off the excess solution for precipitation. Agitation with solution is not a new idea, it was practised in the early days in the Black Hills. The method has some similarity to the Adair-Usher process formerly used in South Africa.[1] A number of serious objections may be urged against the method, chief of which is the great amount of low-grade solution to be precipitated and the fact that agitation and decantation are such radically different operations that it is difficult to see how they can be successfully combined. Leon P. Hills[2] describes a system of agitation in Pachuca tanks, by the charge system, but combined with a continuous flow of solution through the agitators while the pulp is in agitation. The decanted solution is in reality a thin pulp and passes to a thickener or settler, the clear solution overflow from which is returned to the agitation tanks after precipitation if necessary. A modified form of Pachuca tank is proposed for this work, which has been described.[3] J. M. Nicol[4] describes a system of hydraulic agitation very similar in principle to that of C. F. Spaulding, just described. H. A. Megraw[5] discusses slime agitation in general, and describes the new Dorr agitator which is meeting with success. This agitator has a central shaft carrying two arms with rakes, set at an incline toward the center of the bottom of the tank. These arms are hinged to the central shaft so that they may be raised when agitation is stopped, and again gradually lowered when it is started again. The central shaft is a tube, and acts as an air lift. It terminates just below the upper level of the tank and discharges into a launder, which distributes the pulp over the surface of the tank. The air pipe for operating the lift is inserted through the bottom of the tank, there being no step bearing for the central shaft, the weight being carried on a truss above the tank. The pulp settling to the bottom is forwarded by the rake to the central lift column, where it is raised by the air, and again distributed over the surface of the tank. The agitator tank has a large area and small depth so that low-pressure air may be used. The consumption of power is low. It would seem that all particles of solids are certain to receive agitation. The agitator certainly seems a most rational and simple device. J. A. Carpenter[6] discusses continuous agitation in Trent agitators at the West End mill, Tonopah. He classifies agitators as follows: (1) Those using a cone-bottomed vat the motive power being (a) compressed air; *e.g.*, the standard

[1] MINERAL INDUSTRY, XVII, 449.
[2] *Mex. Min. Jour.*, XVII, 327; *Min. Sci. Pr.*, CVI, 241, 421, 663, 955.
[3] MINERAL INDUSTRY, XX, 339.
[4] *Min. Eng. World*, XXXVIII, 1133.
[5] *Eng. Min. Jour.*, XCVI, 1161; *Min. Sci. Pr.*, CVII, 193.
[6] *Min. Sci. Pr.*, CVI, 646.

Pachuca and variations from it; (b) solution under pressure; *e.g.*, the Patterson hydraulic agitator; (c) mechanical appliance; *e.g.*, the Hendryx. (2) Those using a flat-bottomed vat, the motive power being (a) compressed air, *e.g.*, the Parall tank; (b) solution under pressure; *e.g.* the Trent agitator; (c) mechanical appliance; *e.g.*, the old arm agitator; (d) mechanical appliance and compressed air; *e.g.*, the Dorr agitator. The paper discussed at some length and with much detail continuous agitation in the Trent agitator. It compares costs between Trent and Pachuca agitators. It is not possible to abstract this valuable paper satisfactorily in the space available and reference should be made to the original article.

Whitman Symmes[1] describes the Symmes agitator. He states that a perfect agitator should give either a strong or weak agitation and aeration, as the pulp may require. It should have no wearing parts in the pulp itself. It should not be subject to interference or injury by the settlement or packing of the pulp. All parts should be readily accessible from the outside of the vat. The Symmes agitator consists of a flat-bottomed vat 24×14 ft. containing a number of air lifts (8), flexibly suspended from a horizontal revolving arm. This arm is supported on an immovable standard at the center of the vat. The revolving arm may be driven from below through the standard if this be hollow, or it may be driven from above as in the Dorr agitator. The air-lift tubes hang from the revolving arm by means of chains and are so balanced as to remain vertical when the arm revolves. The air lifts discharge at about the middle of the height of the vat and not at the surface of the pulp. The arm makes 1.5 r.p.m. Air is supplied to each tube by a hose connected with a pipe union above the pulp. In the event that the pulp becomes packed on the bottom of the vat, the air lifts will drag and cut their way down through it. If power is cut off for a long time the air-lift tubes can be raised by means of chains. Compressed air is used at a pressure of from 8 to 12 lb., and the agitator requires from 60 to 70 cu. ft. of free air per minute for ordinary working. Considerable detail is given in the original paper.

D. F. Irvin and V. G. Hills[2] describe the ability of the Pachuca agitator to start agitating readily after a prolonged shut-down. H. B. Wright[3] describes the Wright-Jaentsch slime agitator. The agitator consists of a flat-bottomed tank 20 × 4.5 ft. in which is placed a set of lift pipes 6 in. diameter fixed on a framework which is revolved from a standard at the center of the vat. The lift pipes are set at an angle of 45 deg. on the framework inclining outward to the periphery of the tank. They

[1] *Min. Sci. Pr.*, CVII, 92, 467.
[2] *Min. Sci. Pr.*, CVII, 821, 976.
[3] *Min. Sci. Pr.*, CVII, 464; *Eng. Min. Jour.*, XCVI, 644.

are open top and bottom, the bottom opening being turned in the direction of rotation. When the framework with its lift pipes is revolved so that the outside ends of the pipes have a peripheral speed of 350 ft. per minute, the centrifugal force set up causes the pulp to enter the lift pipe at the bottom and be discharged at the top. The number of revolutions per minute is from 6 to 7 and the agitator requires 3 h.p. Twenty-three of these agitators are in operation at the Great Boulder Perseverance Mines, Western Australia. A. W. Warwick[1] has been granted a patent on a new form of pulp agitator. W A. Hendryx[2] gives the results of tests by the Hendryx agitator on Rand ore, both sand and slime. Bernard MacDonald[3] describes improvements on the Parral tank. John Gross[4] describes a small Pachuca agitator which has been found satisfactory for laboratory tests on slimes. The Dorr agitator and thickener[5] consists essentially of the Dorr agitator, already described, with the addition of a cone baffle surrounding the air lift. This device confines the thickened pulp within the baffle cone from which it is continuously drawn off by a suction pipe near the top.

Thickening and Filtering.—C. A. Banks[6] describes a dewatering tank or thickener for slime. It consists of four conical bottomed tanks each 17 ft. square with the cones of each pair of tanks connected to a disintegrator in which the thickened slime discharged from the filter leaves is mixed with cyanide solution for transfer to agitators. Each tank contains fifteen 16×4.5 ft. Moore filter leaves, the total filtering area being 9000 sq. ft. The dewatering operation is a matter of collecting and discharging the slime cakes. The capacity is 700 tons of slime per day. R. Hayden[7] describes a centrifugal slime thickener that might be applied to cyanidation work. The apparatus is known as the Kuchs-Laist slime thickener. H. N. Spicer[8] discusses the action of baffle plates in tanks for slime settling, as an aid in settling, and from the inspection of a considerable number of such devices arrives at the conclusion that baffles are hindrances rather than aids. A. G. French[9] proposes to add glue to slime pulp to aid in the rapid settling of slime. A very weak solution of gelatin or common glue, 1 part glue to 250 water, is added in small amount to the pulp. When sulphates are absent in the slime pulp, zinc, iron or copper sulphate is added, one part for each part of glue. The slime particles are said to become coated with an impervious coating, and to settle rapidly. It is questionable whether the method is applicable to

[1] *Eng. Min. Jour.*, XCVI, 166; *Met. Chem. Eng.*, XI, 292.
[2] *Min. Sci. Pr.*, XCVI, 151.
[3] *Eng. Min. Jour.*, XCVI, 928, 1134, 1183.
[4] *Min. Sci. Pr.* CVI, 544.
[5] *Met. Chem. Eng.*, XI, 715.
[6] *Min. Sci. Pr.*, CVII, 154.
[7] *Trans. Am. Inst. Min. Eng., Bull.* 80, 1457; *Min. Mag.*, IX, 221
[8] *Min. Sci. Pr.*, CVI, 954.
[9] *Eng. Min. Jour.*, XCVI, 307.

cyanidation. G. F. Spaulding[1] gives two curves, one for determining the percentage of solids in pulp when the specific gravity of the pulp and that of the solids is given and the other for determining the number of cubic feet of pulp to the ton when the specific gravity of the pulp is given. H. N. Spicer[2] describes in detail the evolution of methods in handling slime at the mills in India, New Zealand, Australia, the Rand, and Rhodesia. The notes are of much interest and are the result of visits to the several districts. A. W. Allen,[3] the editor[4] and R. Ellis[5] discuss the question of colloids and its importance in ore dressing and cyanidation. A. W. Warwick[6] discusses a theory and practice of washing metallic values and cyanide from slime cakes. The following statements are made: "The methematical laws governing the washing of laboratory precipitates enunciated by Bunsen do not apply to filter cakes. Nor do the familiar arithmetical rules used in connection with decantation have any direct bearing except perhaps when considering the solution mechanically retained in the leaves. These considerations arise from the fact that in removing the soluble values from slime cakes the principle of displacement is used rather than the laws of continuous or repeated dilution." On this basis a wash equal in volume to that of the moisture retained in the cake plus the solution in the filter basket, will entirely displace all soluble values retained by the unwashed cake, providing the cakes were of uniform permeability. In such correctly formed cakes, the wash water would pass through like a wall pushing the pregnant solution before it. The only loss in this instance is the valuable solution which has actually been absorbed by the minute particles of porous lime. In practice a wash equal in volume to the moisture in the cake and filter leaves will recover 80 to 85 per cent. of the dissolved values left in the slime cake. This is an insufficient recovery, as it should be 98 to 99+ per cent., and a volume of wash equal to 1.5 to 2 times that of the retained solution must be used. This is too large an amount of water to add to the mill solutions, but if the larger part of this wash is barren solution, low in cyanide, and only a part water, a high recovery of dissolved metal is made, with a low loss in cyanide, and with no disturbance of the solution balance in the mill. These are the principles on which the washing of filter cakes is based. In practice the completeness of washing depends upon (1) the nature of the slime; (2) value of the solution to be recovered; (3) volume of washes employed; (4) freedom of cakes from cracks; (5) condition of filter leaves; (6) extent to

[1] *Min. Sci. Pr.*, CVI, 700.
[2] *Met. Chem. Eng.*, XI, 181, 239, 315, 408, 451, 481.
[3] *Min. Sci. Pr.*, CVII, 109.
[4] *Min. Sci. Pr.*, CVII, 87.
[5] *Min. Sci. Pr.*, CVI, 209
[6] *Min. Eng. World*, XXXVIII, 665, 797, 1135.

which "blowback" occurs. The speed of washing is governed by the filtering rate, *i.e.*, the volume of solution passing through each square foot of filtering surface per minute. The filtering rate in turn depends upon (1) the nature of the slime; (2) thickness of the cake; (3) difference of pressure between the two sides of the filtering medium and (4) condition and design of filter leaves. Charles Butters[1] describes a modified vacuum filter leaf and a method of discharging slime cakes from the leaf. A comparatively smooth filtering surface is used, and the formed cake is made dryer than usual by maintaining a high vacuum for 5 to 10 minutes while the cake is suspended in air. This reduces moisture to about 20 per cent., and the cake tends to crack at the top, thus beginning a separation of the cake from the filter. Vacuum is now shut off and if water is applied at the top of the cake, by means of a perforated pipe which is supported above the header of each leaf, the slime cake is readily and completely dislodged. M. W. von Bernewitz[2] discusses the concentration of dissolved metal at the surface of slime ponds and its recovery at Tonopah, Nev., by scraping the surface of the slimes. An editorial[3] mentions the cleaning of filter cloths by means of a sand blast in place of an acid wash.

The reciprocating type of Ridgeway filter[4] is used to a considerable extent in western Australia. It consists of two rectangular tanks placed about 7 ft. apart between which is a vertical shaft carrying two strong arms from one side of each of which are suspended 20 filter frames which are balanced on the other side by heavy weights. This system can be made to revolve by worm gearing and the frames may be lowered into the pulp or solution. One tank is used for loading the frames and the other for washing them. Wm. MacDonald[5] describes vacuum filtration at the Victoria mill of the Waihi Gold Mining Co., New Zealand. A Moore type of vacuum filter is in use with a special design of leaf. The interior of the leaf is corrugated iron instead of cocoa matting. The filter operates on a very siliceous light weight slime. Patents have been granted to the Just Process Co.[6] for a revolving drum filter using silica sponge brick as the filtering medium; to T. Breakell[7] for a rotary vacuum filter; to R. P. Akins[8] for a rotary drum vacuum filter, to H. E. Kier[9] for a leaching filter tank; to G. J. Young[10] for a continuous vacuum filter; to U. A. Garred[11] for a continuous vacuum filter for thickening pulp; to W. Mauss[12] for a centrifugal filtering machine. R. H. Shaw[13] describes a type of simple air lift, that may readily be taken apart for the removal of obstructions

[1] *Min. Sci. Pr.*, CVII, 935.
[2] *Min. Sci. Pr.*, CVI, 145.
[3] *Met. Chem. Eng.*, XI, 228, 217.
[4] *Min. Sci. Pr.*, CVI, 993.
[5] *Jour. Chem. Met. Mn. Soc. So. Afr.*, XIV, 67, 171; XIII, 537; *Min. Sci. Pr.*, CVII, 617.
[6] *Met. Chem. Eng.*, XI, 159.
[7] *Met. Chem. Eng.*, XI, 459.
[8] *Met. Chem. Eng.*, XI, 345.
[9] *Met. Chem. Eng.*, XI, 345.
[10] *Met. Chem. Eng.*, XI, 292.
[11] *Met. Chem. Eng.*, XI, 657.
[12] *Eng. Min. Jour.*, XCVI, 647.
[13] *Min. Sci. Pr.*, CVII, 861.

M. W. von Bernewitz[1] describes methods of handling pulp at Tonopah and Goldfield, Nev., by means of three throw plunger pumps, bucket elevator, tailings wheel, centrifugal pump and Frenier pumps, giving considerable detail. G. J. Davis and C. R. Weidner[2] publish valuable data on the air-lift pump, of interest to cyanide metallurgists. W. B. Rhodes[3] describes the installation of two air lifts, replacing centrifugal pumps at the property of the Compania Minera Jesus Maria y Anexas, at San Jose de Gracia, Sinaloa, Mex. These pumps handled a gritty pulp to greater advantage than centrifugal pumps.

Patent Litigation

The Filter Litigation.—The Moore Filter Co. and the Oliver Continuous Filter Co.[4] have adjusted differences between themselves. Both filters will be sold by each company, sales to be upon a basis of lowest permissible first cost with a tonnage royalty graduated according to the richness of the ore. The Moore Filter Co. has brought suit against the Talisman Cons. Co. in New Zealand and the Lord Nelson Co. in Victoria, for unauthorized use of the Moore filter. It is stated[5] that the Chamber of Mines of western Australia has raised a fund to combat the claims of the Moore Co. The Moore Filter Co.[6] brought action against the Butters Vacuum Filter Co. in the U. S. District Court for southern New York to prevent the Butters Co. from doing business at its N. Y. office. Upon the defendant's showing that no business had been done the case was dismissed. The Golden Cycle Mining Co.[7] of Colorado, using a Butters filter, some time ago made settlement with the Moore Filter Co. for use of the vacuum filter and has now been sued by Charles Butters for infringement of the Butters patents. The Gold Ore Treatment Co.[8] and the London and Hamburg Gold Recovery Co., Ltd., owners of the Sulman-Teed and Goepner and Witter bromo-cyanogen patents, brought suit against the Golden Horseshoe Estates Co., Ltd., Australia, for infringement of patents during 1907 and 1908. The court declared the Sulman-Teed patent invalid and upheld the Goepner-Witter patent. Both sides have appealed to the Privy Council in England against this decision. Joseph A. Vincent[9] owner of patent 781711, granted to Alden H. Brown, Feb. 7, 1905, brought suit against the Tonopah Mining Co. in 1911 for infringement of patent. The Brown patent makes the follow-

[1] *Min. Sci. Pr.*, CVI, 282.
[2] *Univ. of Wis. Bull.*, 450; *Eng. Series*, Vol. VI, No. 7; *Met. Chem. Eng.*, XI, 118, 129.
[3] *Mex. Min. Jour.*, XVII, 348.
[4] *Min. Sci. Pr.*, CVI, 537.
[5] *Eng. Min. Jour.*, XCV, 821.
[6] *Eng. Min. Jour.*, XCV, 967, 1018, also 454, 816.
[7] *Min. Sci. Pr.* CVII, 877.
[8] *Min. Sci. Pr.*, CVI, 986, CVII, 407.
[9] *Min. Sci. Pr.*, CVII, 292; *Eng. Min. Jour.*, XCVI, 559; *Met. Chem. Eng.*, XI, 541, XII, 219.

ing two broad claims. (1) The herein described process for the treatment of ore consisting in first pulverizing the ore in the presence of cyanide solution; second, subjecting the ore to hydraulic classification by the introduction of cyanide solution at the bottom of an overflow tank to produce an ascending current; third, leaching the ore by the use of cyanide solution whereby the finer values of the ore are dissolved; fourth, removing the dissolved metallic values in any suitable manner; and finally subjecting the residue of ore to concentration. (2) A process of treating sulphide ore consisting first in subjecting the raw or unroasted ore to the action of a cyanide solution whereby the finer metallic values are dissolved, and second, subjecting the ore or tailings to concentration whereby the coarser values are recovered.

The Tonopah Mining Co. uses the cyanide process in the following form: rough crushing, stamping in cyanide solution, classifying in cyanide solution, sand reground in Huntington mills, product from which joins classifier overflow which is concentrated on tables, pulp from tables reclassified, and treated as sand by leaching, and slime by agitation and filtration. The plaintiffs contended that this process infringed the Brown patent. The suit was really based on the more detailed first claim than on the broader second claim, the contention of the plaintiffs being that to all intent and purposes the regrinding in Huntington mills was leaching, ignoring the final treatment of sand and slime. The suit was a very important one in so far as the upholding of the patent would affect a great many milling companies. In October, 1913, the United States District Court for Delaware, Judge Edward G. Bradford, decided that the Tonopah Mining Co. infringed the patent of Alden H. Brown. However, in March, 1914, the United States Circuit Court of Appeals reversed this decision, and without passing on the validity of the Brown patent, ruled that there was no infringement.

The Chemistry of Cyanidation

Morris Green[1] experimented to determine the effect of oxidizers on the solution of gold by cyanide. His conclusions are as follows: (1) $K_2Mn_2O_8$ destroys cyanide, as is well known, and does not aid in the solution of gold; (2) $K_3Fe(CN)_6$ in water solution is not a solvent for gold, but when added to cyanide solution accelerates the solution of the gold markedly. From the experimental work performed it is probable that the following reaction occurs when ferri-cyanide is added to KCN.

$$2K_3Fe(CN)_6+3KCN+H_2O=2K_4Fe(CN)_6+KCNO+2HCN$$

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 355, 421, 541; XIV, 65; *Eng. Min. Jour.*, XCV, 1233; XCVI, 392.

The destruction of cyanide is very marked, and it is to be noted that the use of ferri-cyanide as an oxidizer really produces a reducing agent, $K_4Fe(CN)_6$ in the solution, and hence its use is not desirable. The accelerating action of $K_3Fe(CN)_6$ on the solution of gold is not due to any products of the reaction between it and cyanide, according to the author but according to J. Moir is due to the action of nascent CN as in the bromo-cyanogen reaction. (3) KCNO in water has no solvent action on gold. Its presence in cyanide solutions has no influence on the dissolution of gold. (4) Excess free oxygen in solutions retards the dissolution of gold. This confirms the statement of Julian who holds that oxygen plays no primary part in the dissolution of gold by cyanide and that free oxygen often exerts a retarding influence. This reopens an old discussion, and the evidence presented cannot be considered conclusive. In discussion of this paper W. B. Chomley states that under certain conditions when oxidizing agents are present NH_3 is a product of the reaction between these and cyanide. This NH_3 interferes with the determination of KCN by $AgNO_3$, and may even indicate the presence of KCN when it is absent. This explains the non-solvent action of certain solutions which apparently contain cyanide. John Gross[1] gives data on the solubility of a natural alloy—60 per cent. gold and 40 per cent. silver, in a 4-lb. KCN solution, renewing the solution daily. The particles varied from very fine to 1/16 in. diameter. At the end of 20 days, 85.23 per cent. were dissolved. J. J. Andrejew[2] states that in 0.25 per cent. KCN solution the rate of solution of gold is increased by very dilute ozone, but markedly decreased by more concentrated ozone—3 to 4 per cent. The cause of the decrease is the formation of a visible layer of gold oxide. H_2O_2 acts in a similar manner, although a large excess of H_2O_2 or a mixture of H_2O_2 and O_3 increases the rate. In very dilute cyanide solutions (0.01 to 0.05 per cent.) even atmospheric oxygen will cause a formation of gold oxide and cause the rate of solution to decrease. H_2O_2 added in any quantity does not decrease the rate of solution of Ag. Ozone alone in KCN solutions has a very slight effect on Ag, but in combination with H_2O_2 raises the rate of solution. J. J. Denny[3] describes his "desulphurizing" process for gold-silver ores in use at the Nipissing low-grade mill at Cobalt, Can. The essentials of the process are (1) extremely fine grinding, so that only 0.5 per cent. remain on a 200-mesh screen. (2) A preliminary reducing treatment before cyanidation, which consists in crushing the ore in a 0.25-lb. caustic soda solution, plus 5 lb. lime per ton ore, then passing the pulp through a tube mill containing aluminium ingots, then agitating it in stock tanks for 10 hours in the presence of pure aluminium plates. From the stock

[1] *Eng. Min. Jour.*, XCV, 749.
[2] *Zeit. Electrochem.*, XIX, 667; *Eng. Min. Jour.*, XCVI, 1225; *Min. Sci. Pr.*, CVII, 889.
[3] *Min. Sci. Pr.*, CVII, 483, 484.

tanks the pulp is withdrawn for filtering, the filtered pulp containing 26 per cent. alkali solution as moisture. (3) Cyanide treatment by agitation with 0.25 per cent. KCN solution, 2.5 solution to 1 of solids, settled and decanted, and then agitated with more solution. The pulp is then filtered. (4) Precipitation of solutions by means of aluminium dust. An advantage in the use of caustic alkali in the crushing solution is that it is necessary in the precipitation by aluminium. The ore treated has the following composition: Ag, 0.106 per cent.; Cu, 0.270; As, 1.88; Fe, 1.92; S, 0.64; Bi, 0.01, Ni and Co, 0.73; Pb, 0.064; CaO, 9.02; MgO, 4.33; Al_2O_3, 10.03; CO_2, 11.06; insoluble, 59.84; Hg, trace. In July, 1913, the mill treated 234 tons per day of 27 oz. ore making an extraction of 93.16 per cent. The desulphurizing treatment makes an extra saving of 1 to 4 oz. per ton at a cost of 54 cents per ton. The theory of the process is that the nascent hydrogen evolved by the action of NaOH on Al, thus, $2Al+2NaOH+2H_2O=Na_2Al_2O_4+6H$, acts on complex silver minerals, which are in an extremely fine state of division, reducing the silver in these to metallic silver, thus, $Ag_3SbS_3+6H+6NaOH=3Na_2S+6H_2O+3Ag+Sb$. The question, however, is left open for future investigation. In the experimental work, pure silver minerals were taken and ground with quartz to pass a 100-mesh screen. The amount of mineral taken was such as to make an ore of about 30 oz. The accompanying table gives the results of treating these artificial ores with ordinary cyanide solution, with cyanide and lead acetate and by the Denny process.

SOLUBILITY OF SILVER MINERALS.

Mineral.	A. Plain cyanide. 0.25 per cent. KCN; 3 parts solution to 1 of ore; 5 lb. CaO per ton. 48 hours agitation.		B. Plain cyanide plus lead acetate. Same conditions as A.	C. Desulphurising and plain cyanide. Same conditions as A.
	Ag. oz. per ton.	Extraction, Per cent.	Extraction, Per cent.	Extraction, Per cent.
Pyrargyrite	27.40	28.46	18.24	88.70
Proustite	31.40	57.90	32.70	98.00
Tetrahedrite	29.97	19.20	5.80	78.50
Argentite	26.70	69.28	97.97	80.59

G. H. Clevenger and M. L. Hall[1] discuss the application of electrolysis to cyanide solutions as an aid in dissolving precious metal and arrive at the conclusion that the effect of electrolysis in most cases is an increased consumption of cyanide and the formation of a coating of calcium carbonate on the ore particles which may interfere with extraction. Other interesting conclusions are arrived at. E. F. Kern[2] discusses the same

[1] *Min. Sci. Pr.*, CVII, 927.
[2] *Min. Sci. Pr.*, CVII, 577.

subject and arrives at similar conclusions. M. W. von Bernewitz[1] and V. C. Bennett discuss the use of lead salts in cyanidation giving the mill practice in use at many plants. John Watson[2] discusses the effect of the addition of $CaSO_4$ to cyanide solution. He finds a well marked but not great destruction of cyanide takes place due to the addition of the salt. Magnesium sulphate causes a very decided destruction of cyanide. A. W. Allen and J. S. Colbath[3] discuss the question of the reliability and the correctness of the $AgNO_3$ titration for mill solutions, and in general the chemical determinations in use for solutions control. G. H. Clevenger[4] describes a rapid volumetric method for the determination of silver in mill solutions. The method is based upon the fact that when a cyanide solution containing silver is filtered through a thin layer of zinc dust, the silver is completely precipitated. The precipitated silver and remaining zinc are dissolved in nitric acid, and the silver determined by the Volhard volumetric method. Mercury interferes, and metals whose salts are colored, as Ni and Co, should not be present. Copper may be present in amount equal to the silver. The method checks well with the fire assay. J. E. Saul[5] describes a delicate qualitative reaction for gold. If one volume of a 0.1 per cent. solution of p-phenylenediamine is added to 10 volumes of a 0.0001 per cent. $AuCl_3$ solution a distinct greenish-yellow coloration is observed. C. B. Brodigan[6] describes the Dowsett test for gold in cyanide solutions, which, however, seems complicated for a mill test. J. E. Clennell[7] gives valuable notes on the method of analysis of zinc dust, amplifying the work on this subject by Sharwood. The accompanying table gives analyses of zinc dusts.

ANALYSIS OF ZINC DUST.

Constituent.	Sample A. Per cent.	Sample B. Per cent.	Sample C. Per cent.
Metallic zinc	84.33	83.29	84.71
Zinc oxide	10.70	13.38	14.13
Lead	0.59	2.44	1.76
Cadmium	0.52	0.17	1.03
Iron	0.22	0.05	0.06
Carbon	2.04	0.04	0.03
Silica	0.33	0.13	0.08

A. M. Merton[8] describes specifications and tests for zinc dust. C. A. Browne[9] describes the manufacture of NaCN from beet-sugar residues.

[1] *Min. Sci. Pr.*, CVII, 757, 154.
[2] *Met. Chem. Eng.*, XI, 51; MINERAL INDUSTRY, XXI, 417; *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 55.
[3] *Min. Sci. Pr.*, CVII, 448, 582.
[4] *Eng. Min. Jour.*, XCV, 892, 914.
[5] *The Analyst*, XXXVIII, 54; *Min. Eng. World*, XXXVIII, 772.
[6] *Eng. Min. Jour.*, XCV, 805, *Trans. Inst. Min. Met., Bull.* 101, 1913.
[7] *Eng. Min. Jour.*, XCV, 793, 1108; MINERAL INDUSTRY XXI, 421.
[8] *Min. Eng. World*, XXXVIII, 1227.
[9] *Min. Sci. Pr.*, CVII, 186; *Met. Chem. Eng.*, XI, 600.

Two factories in Germany produce annually about 5000 tons from this source. The South African Engineering Standards Committee[1] has issued Pamphlet No. 3 which contains information concerning the sampling of lime and the determination of available alkalinity. To determine alkalinity, a sample from the sampling works, crushed through 30 mesh and kept in an air-tight bottle, is taken, crushed through a 60-mesh screen as quickly as possible and placed in a dry wide-mouthed bottle with a tight stopper. Two grams of this sample is agitated continuously with one liter of a 2 per cent. cane-sugar solution for 2 hours. Then filter and titrate aliquot portions with N/10 acid solution using rosolic acid as an indicator. The distilled water used must be made neutral to rosolic acid. A. M. Merton[2] discusses the use of lime in cyanide work and gives method for the determination of available lime and tables of the solubility of lime in water and in sugar solution.

Precipitation and Treatment of Precipitates

E. M. Hamilton and S. F. Kirkpatrick[3] describe aluminium precipitation. E. M. Hamilton describes the process in use at the low-grade mill of the Nipissing Mines Co., Cobalt, Ont. It was found that when treating the complex silver ore by cyanidation, using zinc as a precipitant, the solutions rapidly deteriorated and lost their dissolving power. The cause for this was shown to be the presence together in the solution of considerable zinc and arsenic. Aeration and addition of oxidizers gave no improvement. An analysis of a mill solution is as follows: KCN (free), 0.09 per cent., alkali (protective, in terms of NaOH), 0.13; Zn, 0.113; KCNS, 0.069; Sb, 0.0025; Cu, 0.021; As, 0.021; Fe, 0.007, Ag, 0.80 oz. It was therefore decided to avoid the combination of Zn and As in solution by the use of aluminium dust. Aluminium precipitation was suggested in 1893 by Carl Moldenhaur who obtained patents on the method. The fact that aluminium does not replace gold in the cyanogen compound makes it necessary to have caustic alkali present, when the following reaction probably occurs, one part Al precipitating 12 parts Ag.

$$(1)\ 6NaAg(CN)_2+6NaOH+Al=6Ag+12NaCN+2Al(OH)_3$$

$$(2)\ 2Al(OH)_3+2NaOH=Na_2Al_2O_4+4H_2O.$$

In practice 1 part Al precipitates 4 parts of Ag and the following reaction may perhaps take place.

$$(3)\ 2NaAg(CN)_2+4NaOH+2Al=4NaCN+2Ag+Na_2Al_2O_4+4H.$$

Former attempts with Al in the form of plates and shavings proved

[1] *Min. Mag.*, VIII, 379.
[2] *Chem. Eng.*, Sept., 1913, p. 113; *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 321.
[3] *Eng. Min. Jour.*, XCV, 935, 1277.

failures, but the application of aluminium dust in 1908 by S. F. Kirkpatrick at the Deloro Mining & Reduction Co.'s plant, Ontario, was successful. Precipitation at the Nipissing mines is carried on in a way very similar to zinc-dust precipitation by the Merrill system except that extra facilities are provided for a violent agitation of solution and dust made necessary by the fact that, the dust is wetted with difficulty and always tends to rise to the top of the solution even after being submerged.

As stated NaOH is necessary in the solution, and before precipitation, the strength in NaOH is brought up to 2 or 3 lb. per ton. Lime added to settle slime must be kept as low as possible to avoid the formation of insoluble calcium aluminate which collects in the filter press. Precipitation is very good, usually 98 to 99 per cent. and the consumption of Al is about 0.32 oz. per oz. of silver. Using a 0.2 per cent. cyanide solution containing on the average 8.5 oz. per ton the regeneration of cyanide ranges from 0.64 to 0.72 lb. per ton of solution. The precipitation product ranges from 85 to 92 per cent. Ag, when the lime is carefully controlled. The cost of precipitation is stated to compare favorably with the zinc dust method. S. F. Kirkpatrick gives additional interesting data. J. S. MacArthur[1] describes the precipitation of cyanide solutions by means of zinc wafers, *i.e.*, zinc strips, No. 11 guage, 1.5 in. long and 0.25 in. wide. These are used in zinc boxes in a manner similar to zinc thread and are stated to give very clean precipitate nearly free from zinc. The method has been in operation at the Caveira mine, 70 miles south of Lisbon, Portugal. Experiments made with the method at the Waihi mill, New Zealand and on the Rang gave very poor precipitation, C. W. Merrill[2] has patented a new method of precipitation (Nos. 1,063,568–69–70) which consists in passing precious metal-bearing solution through a tube mill in which are placed balls of a brittle alloy of zinc with other metal. The mill will be lined either with the same material or with an abrasive, like carborundum. W. Symmes and W. E. Trent[3] have patented a new method of zinc-dust precipitation. It consists essentially of a vacuum filter upon which a bed of zinc-dust is placed and through which pregnant solution is drawn. H. S. Munroe[4] describes zinc dust precipitation at the plant of the Black Mountain Mining Co., Cerro Prieto, Sonora, Mex. The article gives interesting detailed data, including cost of precipitation. D. F. Irvin[5] describes the new system of feeding zinc-dust in use at the Tigre Mining Co. in Sonora, Mex. A. M. Merton[6] discusses generally the precipitation of solutions by zinc dust and comments on the wide

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 310, 540; XIV, 265,; *Min. Sci. Pr.*, CVII, 557.
[2] *Eng. Min. Jour.*, XCVI, 308.
[3] *Eng. Min. Jour.*, XCV, 916.
[4] *Eng. Min. Jour.*, XCV, 1085; MINERAL INDUSTRY, XVII, 464.
[5] *Min. Sci. Pr.*, CVI, 861.
[6] *Min. Eng. World*, XXXIX, 429.

introduction of the method. Morris Green[1] made elaborate and careful experiments to determine the precipitating effect of graphite and wood charcoal on cyanide solutions and arrived at the following conclusions: Graphite has no precipitating effect on gold in cyanide solutions; in certain cases it may accelerate the solution of gold. That the precipitating effect of charcoal is greatest in freshly burnt charcoal and is due to the occluded gases, chiefly to the CO and to a lesser extent to the hydrogen. That the gases in charcoal are present in two forms, first those loosely held in the porous mass and which have but a slight precipitating effect and the "occluded" CO and H_2 which are the active precipitating agents. Their effect is due to the manner of existence in the charcoal for CO and H_2 by themselves have but little precipitating effect. John Gross[2] gives valuable and interesting experimental data on the re-solution of gold and silver during precipitation, for details of which reference should be made to the original article.

T. W. Bouchelle[3] describes the electrolytic refining of a very low-grade bullion obtained from zinc precipitation at the Lone Star Mine, Pio Pes district, Nicaragua. The bullion had the following composition: Au, 14.6 per cent.; Ag, 10; Zn, 2; Cu, 73.4. It was cast into anodes $20 \times 12 \times 0.75$ in., which were placed in snug-fitting canvas sacks and suspended in an electrolyte of $CuSO_4.5H_2O$, 17.6 per cent.; H_2SO_4, 5 per cent. in water solution kept at 150° F. The cathodes were sheet lead and connections parallel. The current density was 50 amp. per square foot and the drop of potential across electrodes 2 volts. The silver deposited with the copper and the gold residue obtained was 970 fine in gold. G. H. Clevenger[4] made a study of cyanide precipitates and discusses the source of the various metals in the precipitate and the precautions necessary to obtain high-grade precipitate, so that it may be smelted direct without preliminary treatment and with the minimum amount of flux. An interesting table of the composition of 8 different precipitates is given. H. A. Megraw, Wheeler and G. H. Clevenger[5] discuss the question of the shipment of cyanide precipitate to smelters *vs.* smelting them to bullion at the mill. G. H. Clevenger gives definite data showing the advantage of smelting into bullion, as obtained at the Virginia City, Nev., plant of Butters and Co. A. R. Kenner[6] describes in detail the melting furnace for precipitates used at the Rio Plata mill, Guazapares, Chihuahua, Mex. Charcoal is used as a fuel. H. S. Munroe[7] describes the smelting of precipitate at the Black Mountain Mining Co., Cerro Prieto Sonora, Mex. The method used is practically identical with that em

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 257; XIII, 84, 314, 362. *Trans. Inst. Min. M Bull.* 109, 110, 111.
[2] *Eng. Min. Jour.*, XCV, 911.
[3] *Eng. Min. Jour.*, XCV, 238.
[4] *Eng. Min. Jour.*, XCV, 273.
[5] *Eng. Min. Jour*
[6] *Eng. Min. Jo*
[7] *Eng. Min*

...t the Homestake Min. Co. and described by Sharwood and ...s. H. Jones[2] describes the smelting of precipitate at the Belmont ...opah, Nev. Two double-chamber No. 3 Rockwell furnaces ...oil are employed. The cost is 0.09 cent per ounce bullion. ...s of flue dust from the melting furnace is given.

...ith[3] describes the refining and smelting of precipitate at the ...ilver Peak Mill, Blair, Nev. The method is similar to the ...method except that the briquettes are smelted in the blast ...the bullion cupelled, in place of smelting them down directly ...ling furnace. H. R. Conklin[4] describes the method of han...dle precipitate at the Lluvia de Oro Gold Mine Co., at Lluvia ...ihuahua, Mex.

The Treatment of Concentrate

...utchinson[5] describes the method of treating concentrate, now ...the mill of the Goldfield Cons. Min. Co., Goldfield, Nev. The ...thod was described in a previous volume.[6] The concentrate ...goes a double treatment, first, agitation with solution in the raw ...second, after roasting another agitation with cyanide solution. ...nts have conclusively shown that this double treatment yields ...covery than either treatment alone. The concentrate from 78 ...bles amounting to 6 per cent. of the weight and containing 67 per ...the value of the ore, is collected in mechanical agitation tanks, ...ly described, neutralized with lime and transferred to three ...tanks by centrifugal pumps and is agitated during 8-hour periods ...cyanide solution. The manner of treatment in the Pachuca ...the same as formerly. Five 8-hour periods of agitation and de...on remove 80 to 85 per cent. of the gold. The concentrate pulp ...Kelley filter presses, which give a product containing 12 per ...isture, and which has a value of $25 to $30. This is mechanically ...d to the roaster bins, from which a belt conveyor feeds it to two 54 Edwards duplex furnaces, 112×13 ft. each with a capacity ...ons per day. The capacity per square foot per day is 55 lb. ...t loss is only 1.5 per cent. of the material and of this 1 per cent. ...recovered in the dust chamber. This is very low considering the ...of the concentrate, as the accompanying screen analysis will show: ...mesh, 9.5 per cent.; +150 mesh, 8.5 +200 mesh, 22.5; −200 mesh, ...greater part of the sulphur is in the fine particles. The analy...he concentrate is as follows: SiO_2, 51.6 per cent.; Fe, 19.90; S,

[2] *Inst. Min. Met., Bull* 98 (1912).
[3] *Min. Jour.*, XCV, 1197.
[4] *Min. Jour.*, XCV, 630.
[5] *Eng. Min. Jour.*, XCV, 551, 582, 1001.
[6] *Min. Sci. Pr.*, CVI, 170, 204, 386.
[7] Mineral Industry. XX, 351.

18.93; Al_2O_3, 2.00; CaO, 0.20; MgO, 0.10; Sb, 0.08; Te and Se, 0.46; Cu, 0.50. An analysis of the roasted product is as follows: SiO_2, 54.6 per cent.; Fe_2O_3, 32.20; S, as sulphide, 0.15; S, as sulphate, 0.75; Al_2O_3, 3.00; CaO, 0.20; MgO, 0.13; Cu, 0.60; Te and Se, 0.19; Sb, 0.07. Nine gallons of crude oil is consumed in roasting a ton of concentrate. From the furnaces the roasted product passes to a Baker cooler, and from this, with the addition of water, by bucket elevator of special construction to three 20×12 ft. combined collecting and agitating tanks. The roasted concentrate is delivered to each tank for 24 hours. The charge is then settled and decanted and H_2SO_4 added in the proportion of 20 lb. per ton concentrate. The charge is then agitated for 8 hours, water added to fill the tank, and allowed to settle; when clear, the wash is decanted and fresh water added. Four washes are given in this way, equivalent to 8 tons of wash per ton of concentrate. The wash water is treated for the recovery of the copper. The concentrate charge is then neutralized with lime and transferred by centrifugal pump to one of four Pachuca tanks, 14×25.5 ft. It is agitated with a 2-lb. cyanide solution containing 1.2 lb. CaO, in a manner similar to that described for the raw material. The pulp then passes to a storage tank provided with an agitator, which by a cone feeds a 5×18-ft. tube mill, the product from which is returned to the storage tank by a bucket elevator. This regrinding is continued for 16 hours. After regrinding the pulp passes to Kelly presses and the tailings are sent to waste. The extraction obtained is 98.53 per cent. on raw concentrate containing 6.58 oz. Au, and the cost of treatment is $5.68 per ton. The article gives valuable detail particularly as regards roasting and costs. John Gross[1] describes blanket concentration in connection with cyanidation to avoid the difficulties encountered in amalgamating in cyanide solution.

Miscellaneous

S. Williams[2] proposes to amalgamate gold and silver in ores by agitating the crushed ore with mercury in a solution of potassium sulphate and superphosphate. The addition of the chemicals is said to greatly increase the rapidity of amalgamation. In an editorial the development of the cyanide process is commented upon,[3] and reference made to the need of a process to successfully treat cupriferous gold ores, etc. H. A. Megraw[4] discusses in a comprehensive way the question of the kind of ore amenable to cyanidation. Algernon Del Mar[5] describes

[1] *Min. Sci. Pr.*, CVI, 783.
[2] *Eng. Min. Jour.*, XCVI, 22.
[3] *Eng. Min. Jour.*, XCV, 1161.
[4] *Eng. Min. Jour.*, XCVI, 629.
[5] *Eng. Min. Jour.*, XCVI, 769.

the requirements of small cyanide mills. A. W. Allen and J. B. Stewart[1] discuss the question of the simplification of gold ore treatment. The Gitsham cyanide process[2] makes use of cyanide solutions made acid with H_2SO_4 thus giving rise to HCN. This solution is percolated through the ore, and is then again made alkaline with lime before it is precipitated, after which it is again made acid. At the Liberty Bell mine[3] warm cyanide solutions (85° F.) have been employed since April, 1912, with beneficial effect on the extraction of both gold and silver. The gain in extraction is divided amongst amalgamation concentration, and cyanidation, although the greatest gain is made by cyanidation, particularly as regards the silver. The gain in concentration is due to better settling. By the use of the warm solutions the extraction of the gold was raised 0.79 per cent. and that of the silver 10.57 per cent. E. H. Smith[4] discusses the effect of warming cyanide solutions on the precipitation. This subject has been discussed in a previous volume.[5]

J. E. Clark[6] states that at the King of Arizona mine cyanide solutions warmed by exhaust steam give an increased rate of percolation, enabling more solution to be used in a given time and resulting in an increased saving of 20 to 30 cents per ton. Experiments indicate that the addition of oil to cyanide solutions does not cause a consumption of cyanide. H. A. Megraw, W. J. Sharwood and others[7] discuss the important question of the manner of determining the percentage of extraction in cyanide mills. In many plants this is done by considering the bullion recovered plus the content of tailing discharged as making 100 per cent. One reason for this is the difficulty of obtaining a satisfactory heads sample, due to the process employed or the nature of the ore. The methods employed at the Homestake plant are fully outlined by W. J. Sharwood. D. F. Irvin[8] discusses the same subject and describes methods of sampling in vogue for ore, sand, slime, concentrate, solution, etc. E. L. Bateman[9] discusses the use of the Caldecott sand filter table on the Rand and gives interesting data concerning its use. The table is in use at 8 mines and the tonnage handled in this way is 474,400 per month, or about 20 per cent. of the total Rand tonnage. A simple pulp distributor,[10] consisting of a central well the walls of which are perforated by a number of holes equal to the number of separate streams of pulp desired is in use at Stratton's Independence mill, Victor, Colo. H. P. Flint[11] descibes a wire sampler

[1] *Min. Sci. Pr.*, CVII, 254, 466.
[2] *Min. Mag.*, VIII, 64; *Min. Eng. World*, XXXVIII, 654.
[3] *Met. Chem. Eng.*, XI, 98.
[4] *Eng. Min. Jour.*, XCV, 579.
[5] MINERAL INDUSTRY, XIX, 318.
[6] *Min. Sci. Pr.*, XCV, 150.
[7] *Eng. Min. Jour.*, XCV, 1109, 1255; XCVI, 31, 441, 937, 1230; *Min. Sci. Pr.*, CVI, 701.
[8] *Min. Sci. Pr.*, CVI, 514.
[9] *Met. Chem. Eng.*, XI, 672.
[10] *Eng. Min. Jour.*, XCV, 280.
[11] *Eng. Min. Jour.*, XCV, 709.

for automatically sampling solutions. Justin H. Haynes[1] gives a curve showing relation between size of pipe and quantity of solution. P. T. Morrisby[2] describes a siphon for cyanide vats. R. B. Elder[3] describes an ingenuous sampler for cyanide solutions, and gives methods of sampling and plotting data showing the dissolution of gold, strength in cyanide, etc., during leaching. W. H. Kritzer[4] gives directions for first aid in cyanide poisoning. The treatment rate schedule of the Argo mill at Idaho Springs is given in the reference cited.[5]

Cost of Milling

Detailed costs of milling have been published for the following mines: Consolidated Mercur,[6] Utah; Portalnd Gold Mining Co.,[7] Colo.; Camp Bird Mine,[8] Colo.; Liberty Bell Mine,[9] Colo.; Standard Cons. Mine,[10] Calif.; North Star Mines Co.,[11] Calif.; Pittsburgh-Silver Peak Mining Co.,[12] Nevada; Montana-Tonopah Mines Co.,[13] Nev.; Tonopah Mining Co.,[14] Nev.; Tonopah Extension Mining Co.,[15] Nev.; Cost of cyanid ing at Tonopah,[16] Nev., Tonopah Belmont mill,[17] Nev.; Nevada Hills Mining Co.,[18] Nev.; Goldfield Cons. Co.,[19] Nev.; Treadwell group,[20] Alaska; Dome Mines,[21] Canada; Hollinger Mines,[22] Canada; Nipissing Mines Co.,[23] Canada; Santa Gertrudis Co.,[24] Mexico; San Francisco Mill,[25] Pachuca, Mex.; El Tigre Mine,[26] Mex.; El Oro Mine,[27] Mex.; Cost at a French Gold Mine;[28] Costs on the Rand;[29] Rand mining and milling costs;[30] Eldorado Banket Mine,[31] Rhodesia; Oriental Consolidated,[32] Korea.

[1] *Met. Chem. Eng.* XI, 705.
[2] *Min. Sci. Pr.*, CVI, 953, and *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 45, 163, 361.
[3] *Min. Mag.*, IX, 300.
[4] *Min.* and *Sci. Press*, CVI, 148.
[5] *Eng.* and *Min. Jour.*, XCVI, 1116.
[6] *Eng. Min. Jour.*, XCV, 23.
[7] *Eng. Min. Jour.*, XCV, 1232.
[8] *Eng. Min. Jour.* XCVI, 1222.
[9] *Eng. Min. Jour.*, XCVI, 1075.
[10] *Eng. Min. Jour.*, XCV, 1003. *Min. Sci. Pr.*, CVII, 312.
[11] *Eng. Min. Jour.*, XCV, 934.
[12] *Min. Sci. Pr.*, CVI, 306.
[13] *Eng. Min. Jour.*, XCV, 859.
[14] *Eng. Min. Jour.*, XCV, 1162; XCVI, 160.
[15] *Eng. Min. Jour.*, XCVI, 210.
[16] *Eng. Min. Jour.*, XCV, 720.
[17] *Eng. Min. Jour.*, XCV, 1004.
[18] *Eng. Min. Jour.*, XCV, 940.
[19] *Eng. Min. Jour.*, XCVI, 124, 125, 151.
[20] *Eng. Min. Jour.*, XCV, 1278; XCVI ,121. *Min. Sci. Pr.*, CVI, 939.
[21] *Eng. Min. Jour.*, XCVI, 217.
[22] *Eng. Min. Jour.*, XCV, 1102; XCVI, 30, 739.
[23] *Eng. Min. Jour.*, XCV, 1004; 1101; XCVI, 159.
[24] *Eng. Min. Jour.*, XCVI, 1160.
[25] *Eng. Min. Jour.*, XCV, 1104.
[26] *Eng. Min. Jour.*, XCV, 1203. *Min. Sci. Pr.*, CVI, 702.
[27] *Eng. Min. Jour.*, XCVI, 121.
[28] *Eng. Min. Jour.*, XCV, 1004.
[29] *Min. Mag.*, VIII, 174.
[30] *Eng. Min. Jour.*, XCV, 329.
[31] *Min. Sci. Pr.*, CVII, 684.
[32] *Eng. Min. Jour.*, XCVI, 1025.

GRAPHITE

By Benjamin L. Miller

Graphite is a black lustrous mineral crystallizing in the rhombohedral division of the hexagonal system according to most mineralogists although some observers have claimed that it belongs to the monoclinic system. The crystals are six-sided and tabular with striated faces. On account of its softness the faces are seldom distinct. When well crystallized in flakes it has a black to steel gray metallic luster which is, however, practically absent in the fine amorphous material. In certain places it occurs in the form of large leaves or blades and less frequently in the form of fibers. The color is steel gray to black and the streak black. Its hardness is about 1.2 and its specific gravity from 2.09 to 2.23. It has a greasy feeling, a perfect basal cleavage, and is opaque. It is easily sectile and flexible, but not elastic. Its fusibility is unknown though probably above 3000° C. It is combustible at temperatures between 650° C. and 700° C. Chemically it consists of pure carbon, thus making it identical in chemical composition with charcoal and the diamond. Impurities are usually present in the natural graphite but these seem to occur between the thin laminæ and to be purely accidental. Iron oxide, combined hydrogen, and clay are the most abundant impurities.

Graphite is a very stable mineral under atmospheric conditions and the soil formed from graphite-bearing rocks always contains flakes or smaller particles of the mineral.

It is common to separate graphite into two classes designated by the two terms "amorphous" and "crystalline." The choice of terms is unfortunate for the reason that all graphite is crystalline carbon and is sharply separated from amorphous carbon. In practice we generally use the term "crystalline graphite" for those varieties that are coarsely crystallized and have a high luster, while "amorphous graphite" includes the varieties in which the particles are so small as to be indistinguishable to the naked eye and the substance has a dull or earthly appearance. Microscopic examination of some so-called amorphous graphites has shown them to contain very small crystals. The distinction between "amorphous" and "crystalline" graphites would thus seem to be merely a difference in size of the graphite particles. "Amorphous" graphite and "crystalline" graphite are both true graphites and yield graphitic acid and consequently, are distinct from amorphous carbon in the form

of charcoal, coke, or coal although to the eye no distinction may be possible between "amorphous" graphite and amorphous carbon.

Occurrence of Graphite

Graphite is one of the few minerals that occurs in nature under widely different conditions and is also produced artificially in many ways. It is found in igneous, sedimentary, and metamorphic rocks, in varying amounts.

Graphite of Sedimentary Rocks.—The statement is frequently made that graphite does not occur in unchanged sediments but this is erroneous. Emerson[1] has described an unmetamorphosed Triassic sandstone in Massachusetts that contains "scales of graphite in considerable number." Obviously graphite occurring in such rocks owes its origin to nearby metamorphic or igneous rocks in which the graphite was formed. Graphite being little affected by weathering agents would not be affected chemically when the containing minerals were decomposed and the rock disintegrated. On account of its softness, however, the graphite flakes are usually ground into such fine particles during transportation that they escape detection in the sediments, especially when mixed with large amounts of other minerals. Perhaps, in places, the black coloring matter of sedimentary rocks, usually supposed to be amorphous carbonaceous matter is, in reality graphite. Since graphite owes its origin to great heat, the graphite occurring in unchanged sedimentary rocks must owe its origin to the disintegration of graphitic rocks of igneous or metamorphic character so that we do not expect to find graphite deposits of any economic importance in unmetamorphosed sedimentary rocks even though later investigations may show its rather widespread presence in such materials.

Graphite of Igneous Rocks.—There has been much discussion concerning the presence of graphite in igneous rocks as a primary constituent of the magmas and many geologists have assumed that the presence of graphite in metamorphic rocks furnished positive proof of the sedimentary origin of such rocks. Such geologists attribute the source of the carbon solely to organisms that were entombed in the sedimentary rocks. Others have held that the presence of graphite in igneous rocks is purely accidental and that the carbon has been picked up from surrounding rocks. While this may account for some graphite found in igneous rocks it surely does not account for all occurrences in these and we must conclude that graphite is an igneous as well as a metamorphic mineral. This question will be discussed more fully under the head of "Origin of Graphite."

[1] Monograph No. XXIX. U. S. Geol. Surv., p. 365.

In igneous rocks graphite occurs in meteorites, in nepheline syenite, in basalt, and pegmatites. It is usually segregated in such rocks, the graphite occurring in comparatively large irregular masses of great purity. This is especially true of the graphite of the pegmatites.

Near Seisholtzville, Berks County, Pennsylvania, graphite is found associated with magnetite in a basic rock, while in Ovifak, Greenland, it is found in basalt in association with native iron.

Graphite of the Metamorphic Rocks.—In the metamorphic rocks graphite occurs most abundantly, and with few exceptions, all the workable deposits of the world occur in such rocks. Gneisses, schists, quartzites, marbles, and slates contain graphite in various places and in variable amounts. Besides we find, in certain places, beds or veins of practically pure graphite which have probably been formed from beds of coal or from veins of asphaltic materials that have undergone metamorphism.

In the gneisses, schists, quartzites, marbles, and slates, the graphite occurs disseminated throughout the rocks either in the crystalline flake form or as amorphous graphite. In most cases the flakes are oriented so that the flat faces are parallel, particularly in the schists, quartzites and slates. In the case of the marbles and also in some of the gneisses the graphite flakes show no orderly arrangement.

The graphite of the slates is almost invariably amorphous, that of the marbles almost always crystalline, while that of the other kinds of rocks may be either crystalline or amorphous.

Where beds of coal have been metamorphosed to graphite by dynamic action or by contact with igneous intrusions the graphite preserves many of the structural characters of the original material. Such graphite is amorphous and is in most cases very pure.

Veins of graphite occur in fissures and are of various widths. In some places veins 6 ft. in width have been reported but seldom do they exceed a foot in width and most of them are much smaller. The purest graphite usually comes from veins. Much of the Ceylon graphite, which is found in veins, contains 99+ per cent. carbon. The vein graphite is crystalline and is fibrous, foliated, or bladed but does not occur in flakes.

Origin of Graphite

Geologists have long discussed the origin of graphite and perhaps more theories have been proposed to account for this mineral than for any other economic product. Even at the present time there is considerable difference of opinion and there is need of additional experimental work before all questions concerning the origin of this widely distributed mineral are conclusively answered.

It is now proved beyond much question that graphite is of organic origin in certain places and of inorganic origin in others. The presence of graphite in rocks of undoubted igneous origin was not considered sufficient proof by some that the carbon was a primary constituent of the original magma as it was thought that the carbon might have been incorporated in the igneous mass as it passed through carbonaceous sediments on its way to the surface. The discovery of graphite in meteorites, however, in which there is complete lack of evidence of any organic material, seems to have convinced most geologists that graphite occurs in Nature as a product of inorganic origin as well as of organic origin. With this question definitely settled there still remains much discussion concerning the origin of particular deposits. Some persons are convinced that a considerable portion of the graphite deposits of the world have resulted from inorganic compounds while others take the position that graphite with such an origin is very rare and represented by but few occurrences.

Uses of Graphite

The uses of graphite are many and are continually increasing. Few people are aware of the great variety of purposes for which it is suited by its peculiar physical and chemical properties.

Its value depends upon its resistance to the action of heat and corrosive agents, its high conductivity of heat and electricity, the thin character of the flakes, their flexibility and softness enabling them to be spread out under pressure to form a smooth and almost frictionless surface or a black glossy coating, its opaque black color and streak, the ease with which the latter may be obtained and its permanent character, and the absence of occluded gases such as are usually present in amorphous carbon.

The average person doubtless believes its principal use is in the manufacture of lead pencils, while that is, at present, one of the minor uses. Although it is impossible to be specific in stating the proportion of the world's supply used for various purposes it seems that the following table approximately represents the proportions in which it is consumed in various manufactured products.

	Per cent.
Crucibles	55
Stove polish	15
Foundry facings	10
Lead pencils	5
Paint	5
Lubricants	5
All other purposes	5

Besides the uses specifically mentioned above, graphite is used in the manufacture of various refractory articles such as muffles, phosphorizers, brazing boxes, stirrers, etc.; in the manufacture of electrical supplies

such as dynamo and motor brushes and resistance rods, electric light carbons, electrodes, rheostats, in dry batteries, etc.; as a covering for powder; as a fertilizer filler; for coloring and glazing tea leaves and coffee beans; in the manufacture of printer's ink and dye for felt hats; as a dressing for belts; for steam packing; in the manufacture of stove or boiler cements; in boilers to prevent boiler scale; and in the manufacture of many other articles most of which are similar to ones mentioned.

Graphite in the United States

Graphite is widely distributed throughout the United States and yet the bulk of product consumed is imported from foreign countries. This is due mainly to the fact that graphite manufacturers have shown a decided preference for Ceylon graphite in the manufacture of crucibles and Mexican graphite for pencils. The difficulty of finding markets for the product, combined with the difficulties of concentration have been effective in retarding the development of the graphite deposits of the country.

The following states contain graphite deposits that have been at least prospected. In most cases materials from these states have been marketed. These are Alabama, Alaska, California, Colorado, Connecticut, Georgia, Idaho, Maine, Massachusetts, Michigan, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, and Wyoming. Besides the above-named states so-called "graphite" has been produced in several other states—Arkansas, Ohio, etc.—but in most, if not all cases, the product is nothing other than carbonaceous shale.

STATISTICS OF GRAPHITE IN THE UNITED STATES.

Year.	Refined Crystalline Graphite.						Amorphous Graphite Production.	
	Production.		Imports.		Consumption (a).			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Tons. 2000 lb.	Value.
1900	4,103,052	$164,122	32,298,560	$1,389,117	36,401,612	$1,553,239	1,045	8,640
1901	3,967,612	135,914	32,029,760	895,010	36,997,372	1,067,921	809	31,800
1902	4,176,824	153,147	40,857,600	1,168,554	45,034,424	1,322,401	4,739	55,964
1903	4,525,700	164,247	32,012,000	1,207,700	36,537,700	1,371,947	16,591	71,384
1904	4,357,927	162,332	25,350,000	905,581	29,707,927	1,067,913	19,115	102,925
1905	4,260,656	170,426	34,914,611	983,034	39,175,267	1,153,460	(b)21,953	80,639
1906	4,894,483	170,866	50,974,336	1,554,212	55,868,819	1,725,098	(b)16,853	(c)
1907	4,586,149	149,548	40,962,000	1,777,389	45,548,149	1,926,937	(b)26,962	138,381
1908	3,433,039	149,763	22,912,714	762,267	26,345,753	876,030	(b) 1,433	75,250
1909	5,669,899	340,194	42,532,851	1,854,459	48,202,750	2,194,653	(b) 5,096	32,238
1910	5,625,132	286,882	50,610,560	1,872,592	56,235,692	2,159,474	(b) 1,407	39,710
1911	4,790,000	256,050	41,404,000	1,495,729	46,194,000	1,751,779	1,223	32,415
1912	3,543,771	187,689	51,286,000	1,709,337	54,829,771	1,897,026	2,063	32,894
1913 (b)	5,064,727	254,328	57,758,400	2,109,791	62,823,127	2,364,119	2,243	39,428

(a) Neglecting the small re-export of foreign product. (b) Statistics of the U. S. Geological Survey. Largely graphitic shale. (c) Not reported.

Although several of the states named have deposits of graphite that appear to be promising, regular production during recent years has been confined to Alabama, New York, Pennsylvania, Rhode Island, and Wisconsin, with occasional productions reported from other states mentioned in the above list.

Alabama.—During the year the Flaketown Graphite Co. and the Quenelda Graphite Co. were in operation. The latter company rebuilt the mill which was destroyed by fire in 1912 and was able to produce a small amount of concentrates during the latter part of the year. The milling process is somewhat different from the one employed in the old mill. The ore, which is taken from open cuts, is passed through the crushers and rolls until it is reduced to a size small enough to pass through a No. 8 mesh screen. It then goes to the dryer. After being dried the smaller particles of sand and the graphite are separated from the coarse sand by means of four 48-in. fans. The material is then put through the washers which are 7 ft. long, 24 in. wide, and 12 in. deep with a space for running water of 6 in. The graphite concentrates which flow off with the water are allowed to drain for a day and then passed through a rotary dryer in which all particles of wood are burned. It is then sorted into 4 sizes on a hexagon reel, each size going to a 48-in. French buhrstone to grind all grit that may adhere to the flakes. It then goes through 8 hexagon reels for further sorting and sizing. Although the mill has been in use a short time it bids fair to be highly satisfactory.

Alaska.—Moffitt[1] has recently described some of the graphite deposits of Seward Peninsula, Alaska, from which the following information is obtained.

Graphitic schists are present in the Nome and Grand Central quadrangles but are of no economic importance. Graphite deposits of considerable size and promising character are found in the headwater areas of Grand Central river and Windy creek and on the north side of the Kigluaik Range west of Cobblestone river.

"A sharp ridge made up of biotite schist striking east and west and intruded by dikes and sills of coarse granitic rock or pegmatite rises on the south from the saddle between the Grand Central and Windy creek. Some of the schist is highly graphitic, the graphite appearing as abundant small scales on the cleavage surface and much of it not being distinguishable on casual examination from flakes of biotite. Locally graphite is segregated in beds or much flattened lenticular masses that conform in direction with the schist cleavage and reach thicknesses of 6, 8 or even 18 in. These beds include thin layers of schist contain-

[1] "Geology of the Nome and Grand Central Quadrangles, Alaska." *Bull.* 533, U. S. Geol. Survey, pp. 135–136, 1913.

ing numerous large garnets and much quartz. The raw graphite found at this place is heavier than the higher grades of graphite, owing to its included quartz."

"The sills and dikes of pegmatite cutting the schist also contain graphite, which is associated with them in such a way as to suggest a close relationship between the intrusives and the graphite. Graphite appears to be an original mineral in the pegmatite as well as to be associated with it in the schist. At one place about 8 in. of solid graphite are included between a pegmatite sill and the overlying schist. The steep slopes of the mountain are strewn with graphite fragments, which, owing to the fact that they are much lighter in weight than either the schist or the pegmatite, appear more abundantly on the surface, especially in gullies where water has brought about a rough sorting. One block, with dimensions of approximately 7 ft., 6 ft., and 30 in., consists of about equal thicknesses of schist and apparently almost pure graphite.

"The graphite-bearing schist extends eastward beyond the east fork of Grand Central river and westward across Windy creek and the head of Cobblestone river to the region south of Imuruk Basin, in which the graphite is even more extensively developed than in the locality described and from which a number of commercial shipments have been made."

California.—Although graphite deposits have been reported from several parts of California very little has been produced to date. In 1901–02 a small amount was mined in Sonoma County but the operations were soon discontinued. In 1913 about 2500 lb. were produced in Calaveras County, which was used in the manufacture of paint. It is said to have been sold for $20 per ton, thus indicating a rather poor quality of material.

Colorado.—During the year an important discovery of graphite was reported from Gunnison County. On Italian mountain three parallel veins were found about 50 ft. apart. The middle vein is said to be from 4 to 6 ft. wide, much of which is pure graphite. The extent of the deposit has not been determined.

Pennsylvania.—The graphite production of Pennsylvania was considerably less in 1913 than in former years. This was due to the fact that only 2 mines were operated—Pettinos Brothers' and the old Pennsylvania Graphite Co's. mine, adjoining properties located in the valley of Pickering Creek near Byers, Chester County. The latter property was operated under lease by John H. Lilly. Both companies were compelled to cease operations by the burning of their respective mills. Pettinos Brothers' mill burned August 2 and the Pennsylvania Graphite Company's mill a few months later. The latter has been rebuilt but not the former.

The mills of the American Flake Graphite Co. near Kimberton and the Eynon Graphite Co. near Coventryville have been dismantled. Plans for the rebuilding of the latter have been prepared. The other graphite properties of the state remained idle during the entire year. Plans have been prepared for the re-opening of some of the abandoned mines and for the construction of a new mill.

New York.—New York continues to occupy the foremost place in the production of flake graphite in the United States. This is due to the fact that the mine of the Joseph Dixon Crucible Co. at Graphite, N. Y., produces an annual yield approximately one-half the total production of the whole United States. Most of the graphite mines of the state were idle as in former years.

Rhode Island.—Graphite shales have been worked for many years at Cranston, which is a suburb of Providence. The graphite is amorphous and contains from 25 to 40 per cent. carbon. The production during 1913 was small and was used for foundry facings.

Wisconsin.—Near Junction, Portage County, is a deposit of graphite shale which is used in the manufacture of paint and lubricants. The Wisconsin Graphite Co. reports improvements in their mines and mills by which they have more than doubled their output.

Artificial or Manufactured Graphite.—The International Acheson Graphite Co. of Niagara Falls, N. Y., again reports the largest production of manufactured graphite in their history. The material is used for a variety of purposes among which the most important are the manufacture of electrodes and lubricants.

PRODUCTION OF MANUFACTURED GRAPHITE 1899–1913.

Year.	Quantity, lb.	Value.	Price per Pound, Cents.
1899	405,870	$32,475	8.00
1900	860,750	68,860	8.00
1901	2,500,000	119,000	4.76
1902	2,358,828	110,700	4.69
1903	2,620,000	178,670	6.82
1904	3,248,000	217,000	6.70
1905	4,595,500	313,979	6.83
1906	4,868,000	312,764	6.42
1907	6,924,000	483,717	6.97
1908	7,385,511	502,667	6.80
1909	6,870,529	467,196	6.80
1910	13,149,000	945,000	7.19
1911	10,144,000	664,000	6.54
1912	12,896,347	830,193	6.44
1913	13,633,342	973,397	7.14

Graphite in Foreign Countries

Graphite is found in almost every region where ancient metamorphic sediments occur. Every continent of the globe and almost every country of prominence contains deposits of graphite that have been worked at one time or another and yet the bulk of the world's production comes from a comparatively small number of localities. Besides the United States,

Canada, Ceylon, Korea, Bavaria, Austria, Italy, Sweden, Norway, and Madagascar furnish practically all the graphite of the world with only occasional production from the other countries.

Canada.—The graphite production of Canada during 1913 was disappointing, as most of the companies were idle and the total production was less than in 1912. The chief difficulties are in the concentration of the graphite flake and the preference of graphite users for Ceylon graphite. The principal operators of the year were the Tonkin-Dupont Graphite Co. of Wilberforce, Ontario and the Black Donald Graphite Co. of Calaboghie. The total production amounted to 2162 tons valued at $90,282.

Ceylon.—The graphite industry of Ceylon during 1913 was less prosperous than in preceding years, with the result that the production decreased and the price increased to a remarkable degree. European importers have been inclined to attribute the cause entirely to local shippers, according to the American Consul at Colombo. The causes for the increased prices seem to be due to the severe floods during the year that greatly interfered with the mining operations, the increased difficulties and consequent expense of mining as the mines increase in depth and more water is encountered, and the shortage of labor.

The following comparative figures, taken from the books of one of the largest exporting firms in the island, show the rise in plumbago prices.

Quality.	January, 1912.	January, 1913.	October, 1913.
	Per Ton.	Per Ton.	Per Ton.
Medium lump	$85.97	$123.27	$162.20
Superior flying dust	45.42	68.13	113.54
Common dust	(a) 25.95	26.76	(b) 66.50
Medium ordinary lump	97.32	134.63	197.88
Superior chip	94.08	131.38	194.64
Superior ordinary lump	154.09	178.42	235.18

(a) 58 to 60 per cent. carbon test. (b) 56 to 57 carbon test.

Uncured plumbago that ordinarily commands about $88 per ton now brings $162 to $195. Recently as much as $260 per ton has been paid for uncured plumbago. The character of this lot was above the ordinary, but after curing 13 cwt. of lump is the best that can be got out of it, and to show a working margin of profit this must bring at least $373 per ton on the market in Colombo, a price that the best lump has not yet reached by over $113.

In the opinion of Colombo shippers the only solution of the difficulty is for all mine owners to abandon as far as possible the old methods and old machinery and equip their mines with modern machinery. The most necessary machine is a mine pump that will pump out 2000 to 3000 gal. per hour with an engine of 25 to 35 h.p. to run it. At present there is

one American pump in the island of a type that gives entire satisfaction. It uses 320 ft. of 9-in. piping and pumps 2000 gal. per hour, with an English-made Hornsby-Ackroyd 20 h.p. engine. The supply of plumbago near the surface has been practically exhausted throughout the plumbago district and the mines in going deeper to get more material have naturally encountered more water. Buckets and hand pumps and coolie labor have been unable to cope with the inflow.

Plumbago is the most important mineral export from Ceylon, and more than one-half of the total output is taken by the United States. The following table shows the destination of the exports during 1912 and 1913:

	1912. Cwt.	1913. Cwt.
United States	309,196	292,524
Germany	161,138	125,691
United Kingdom	106,964	107,060
Belgium	57,474	39,579
Australia	5,681	4,607
Japan	4,407	2,152
France	2,403	2,208
Other countries	3,998	2,123
	651,261	575,944

Korea (Chosen).—Graphite is found in several places in Korea and considerable is exported each year. Most of the material is amorphous, although crystalline graphite deposits are also present in several regions. In some places the industry is hampered by lack of water during the dry seasons and also during the cold season. The most extensive workings are in the southern part of Korea near Fusan where preparations are being made for a greatly increased production.

There are many good deposits of graphite in Chosen district north of Unsan. The material is hand picked and then transported by ponies or bulls a great distance over very rough mountainous roads at considerable expense. Notwithstanding these difficulties the deposits are being worked in a small way by both Japanese and Korean operators.

Most of the Korean graphite is exported to foreign countries by way of Japan and it is therefore difficult to obtain definite figures of the production.

Madagascar.—The graphite industry of Madagascar showed remarkable activity during 1913. During the year 1690 new concessions were registered, while there were only 942 at the close of 1912. These were distributed as follows:

323 in the province of d'Andevorante.
200 in the province of Vatomandry.
194 in the province of Vakinankaratra.
180 in the province of Tamatave.
175 in the province of Ambositra.
168 in the province of Tananarive.
124 in the province of Fianaranteoa.
115 in the province of Itasy.

There are evidently unlimited quantities of graphite in Madagascar, but lack of capital and machinery for concentration and refining have

interfered with the development of the numerous prospects. A market also must be found for the material for undoubtedly there is, at the present time, considerable prejudice on the part of graphite users against the product from any new district.

It is estimated that 8000 tons were produced during the year, of which 6314 tons were exported, the balance accumulating as stock material. It has been claimed that the best product from Madagascar, containing more than 90 per cent. carbon has been sold in Europe and America as Ceylon graphite. The lower grades have been sold as Madagascar material, the effect being to discredit the entire product from the Island of Madagascar. The material is said to sell for $90 and $140 a ton.

The graphite exports from the island during the past 5 years are as follows:

	Metric Tons.
1909	19
1910	545
1911	1247
1912	2732
1913	6314

Russia.—The graphite production of Russia, exclusive of Siberia has always been insignificant. In 1912 a graphite company acquired a graphite deposit near Marionpol in the province of d'Iekaterinoslaw. It is planned to produce about 100 tons per year.

Siberia.—Since the exhaustion of the Alibert Mine, little graphite has been produced in Siberia. During 1913 a party of English engineers was sent to eastern Siberia to prospect for graphite deposits in the Amur region, on the Burei river system. Graphite deposits of promising character are reported to occur near Cape Litke in the Pacific Ocean (Tchnkot Peninsula) and near Eastern Cape in the Primorsk territory.

WORLD'S PRODUCTION OF GRAPHITE.
(In metric tons.)

Year.	Austria.	Bavaria.	Canada.	Ceylon. (a)	India.	Italy.	Japan.	Mexico. (b)	Sweden.	United States. (c)	France and Colonies
1900	33,663	9,248	1,743	19,168	1,859	9,720	94	2,561	84	1,799	.....
1901	29,992	4,435	2,004	22,707	2,530	10,313	88	762	56	1,800	.....
1902	29,527	5,023	993	25,593	4,648	9,210	97	1,434	63	1,895	.....
1903	29,590	3,719	660	24,492	3,448	7,920	114	1,404	25	2,053	.....
1904	28,620	3,784	410	26,478	2,955	9,765	216	970	55	2,045	.....
1905	34,416	4,921	491	31,134	2,361	10,572	209	970	40	1,933	.....
1906	38,117	4,055	405	36,578	2,642	10,805	177	3,915	37	2,220	.....
1907	49,425	4,033	525	33,027	2,472	10,989	103	3,202	33	2,080	.....
1908	44,425	4,844	227	26,227	2,919	12,914	177	1,076	66	1,557	300
1909	40,710	(e)4,900	783	25,995	3,182	11,583	284	1,704	26	5,875	320
1910	33,131	7,415	1,263	30,008	4,319	12,510	145	2,332	49	3,811	1100
1911	41,599	11,298	1,154	27,433	4,047	12,621	114	2,974	65	3,280	1870
1912	45,375	12,532	1,873	33,106	Nil.	13,170	149	2,865	79	3,318	5600
1913	49,456	.....	1,961	29,277	.....	.....	.....	1,057	88	4,331	(e)7000

(a) The figures for 1897, 1899, 1907, 1908, 1912 and 1913 are exports; the enormous production in 1898 as reported in official government publications is not reflected in the exports of that year which amounted to 24,349 metric tons. (b) Exports. (c) Crystalline graphite up to 1909. (d) Includes the production of 7520 metric tons in Korea. (e) Estimated.

South Africa.—The Union of South Africa reports an output of 3 short tons of graphite during 1913.

GYPSUM

By F. A. Wilder

Gypsum was mined in the United States in 1913 to the extent of 2,599,508 short tons, an increase of 98,751 tons over the production of 1912, according to the United States Geological Survey. The total value of gypsum and gypsum products produced in 1913 was $6,774,822, compared with $6,563,908 in 1912, an increase of $210,914. Gypsum sold crude without calcining and used principally as an ingredient in Portland cement and paint and as land plaster amounted to 463,136 short tons, valued at $697,066, which is a good increase over the business of 1912. About 85 per cent. of the gypsum sold crude in 1913 was used for Portland cement as an average value of $1.49 a ton. The quantity sold for this purpose is steadily increasing. The quantity of gypsum sold crude for land plaster has remained nearly stationary for four years, but the average price dropped in 1913 from $2.02 to $1.75 a ton.

PRODUCTION OF CRUDE GYPSUM IN THE UNITED STATES.(a)
(Tons of 2000 lb.)

	1911.		1912.		1913.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Cal., Nev., & Ore.	(b)177,815	$650,319	170,149	$688,247	(c)	.....
Iowa	354,204	857,287	411,186	845,628	456,031	1,157,939
Kansas	122,579	345,203	131,031	324,820	110,410	308,308
Michigan	347,296	573,926	384,297	621,547	423,896	721,325
New York	472,834	1,199,596	506,996	1,241,514	529,627	1,280,699
Ohio and Va.	360,858	1,056,568	262,551	812,388	(e)254,863	695,149
Tex. and Okla.	288,278	773,753	295,937	825,197	308,966	675,165
Utah	(d)	.....	(c)	.....	(c)	.....
Wyoming	44,687	116,237	36,581	89,982	30,632	74,862
All other states	155,419	889,146	302,029	1,314,575	435,968	1,629,439
Total	2,323,970	6,462,035	2,500,757	6,563,908	2,599,508	6,744,822

(a) Statistics of the U. S. Geol. Surv. (b) Includes Utah. (c) Included in other States. (d) Included in Cal. and Nev. (e) Ohio alone; Virginia included in other states.

CRUDE GYPSUM MINED IN THE UNITED STATES. (a)
(Tons of 2000 lb.)

1880	90,000	1892	256,259	1904	940,917
1881	85,000	1893	253,615	1905	1,043,202
1882	100,000	1894	239,312	1906	1,540,585
1883	90,000	1895	265,503	1907	1,751,748
1884	90,000	1896	224,254	1908	1,721,829
1885	90,405	1897	288,982	1909	2,252,785
1886	95,250	1898	291,638	1910	2,379,057
1887	95,000	1899	486,235	1911	2,323,970
1888	110,000	1900	594,462	1912	2,500,757
1889	267,769	1901	633,791	1913	2,599,506
1890	182,995	1992	816,478		
1891	208,126	1903	1,041,704		

(a) Statistics of the U. S. Geol. Surv.

The building trade generally recognizes two sorts of gypsum plasters—cement and wood fiber.

Cement plaster is intended for use with a considerable admixture of sand. The standard specifications adopted 2 years ago by the Plaster Manufacturers propose that six 10-quart buckets of good, clean, sharp sand be added to the hundred pound bag of plaster, for lath work, and a third more sand when the plaster is applied to brick and terra cotta. As a matter of fact, even more sand than is permitted by these specifications is used in the larger cities where bids are taken on narrow margins. To enable the plaster to carry these steadily increasing percentages of sand, the manufacturers have been grinding finer each year, till in 1913 gypsum plaster showed only 5 to 10 per cent. of material that would not pass a 100-mesh screen.

Wood fiber plasters are not sanded as heavily as cement plaster, and manufacturers generally urge their use where sand is poor or expensive and prefer to see them used neat. About 60 lb. of shredded wood take the place of the 4 to 6 lb. of goat hair used in cement plaster.

The use of wood fiber plaster is increasing faster than that of cement plaster, and this is a very satisfactory feature of the industry. Most plaster troubles come from the use of too much sand, or the use of sand of poor quality, so that many architects encourage their patrons in accepting the somewhat higher cost resulting from the smaller yardage secured from wood fiber plaster used neat.

During 1913 there was very little change in calcining methods, only three or four companies using rotary or continuous calciners, the remaining forty adhering to kettle calcining. The product from the rotary calciners, however, seems to be meeting the trade requirements satisfactorily, and the pioneer mills using rotaries will probably establish so satisfactory a reputation for this method that other producers during the next 5 years will take advantage of the saving in costs that the system offers.

In the kettle system of calcining less reliance is placed on the alertness of the operator, and self-recording thermometers are in very general use to indicate clearly when the material has reached the critical temperature of 350° F. (177° C.), at which it should be drawn off.

On account of its tending to "ball" or "gum up," the appliances for fine grinding so satisfactory for Portland cement have not been a success with gypsum plasters. For the same reason certain types of gyratory crushers have not given satisfactory results in the coarse crushing of gypsum. Disintegrators of the hammer or cage type have not met the 1913 requirements for fine grinding of gypsum plasters, and where used they must be followed by regrinders, which are commonly of the buhr or emery type.

The Raymond Mill has been highly successful in gypsum grinding and while a heavy consumer of power, is probably as economical in this respect as any system now in use, since this mill delivers in a single operation a product of remarkable uniformity, over 90 per cent. of which passes a 100-mesh screen.

The use of automatic bag packers is making slow headway in the gypsum industry, due to the difficulties growing out of the clogging of the fiber that is mixed with the plaster. Sixty pounds of wood fiber in a ton of plaster will cause little trouble, but 6 lb. of goat hair cause some annoying shutdowns for cleaning out.

Profits in the gypsum industry in 1913 were unfavorably affected by the prevailing high price of jute which went considerably above the 10 cents per bag which manufacturers commonly charge for the jute container. A special effort was made to push the use of paper bags, but the results were hardly perceptible.

The use of gypsum in Portland cement forms a steadily increasing outlet for the crude material. In contracting for crude gypsum, the cement mill bases its price on the content of sulphur trioxide, which acts as the required retarder for cement. Chemically pure gypsum contains 46.5 per cent. sulphur trioxide. It is common to specify 42 per cent. in contracts with cement mills, this being an analysis that most gypsum mines can consistently maintain, though some material is used as low as 40 per cent. in SO_3. As gypsum is used as a retarder in cement, its uniformity is as essential as its high content in sulphur trioxide.

Experiments have been tried with other substances, and calcium chloride is said to make a satisfactory retarder for Portland cement. As calcium chloride is produced as a by-product in certain industries in amounts far beyond the present market, the supply of this material at many points is ample; but it has not been found possible to dry it and put it on the market at an average price of $1.50 per ton, which is the usual price received at the mine for gypsum analyzing 40–42 per cent. SO_3.

The use of crude gypsum in the form of land plaster as a fertilizer has been declining through many years. Within the last year or two, however, there has been something of a revival of the use of land plaster and in this movement some of the agricultural experiment stations have joined. Excellent bulletins showing the need of restoring sulphur to the soil have recently been published by the experiment stations of Kentucky and Wisconsin. Land plaster, with its 900 lb. of SO_3 to the ton, and its low cost furnishes the readiest means of restoring sulphur to the soil. The placing of sulphur on a like basis with potash and phosphorus in the list of plant foods will mean much to the crude gypsum business.

At present, probably more land plaster is used in connection with the growing of peanuts in a few countries of Eastern Virginia and North Carolina than is used elsewhere in the entire country. About 20,000 tons of this land plaster are ground at Norfolk from anhydrous gypsum brought down from Nova Scotia.

The manufacture of Keene's cement is making considerable progress in the United States and importations of this gypsum product are steadily decreasing.

Gypsum boards are to some extent taking the place of lath and a considerable expansion of the gypsum industry is manifest along this line.

Gypsum blocks are successfully competing with hollow tile, and on account of their greater lightness and superior smoothness have many advocates.

Flooring gypsum is not produced in any quantity in America, though in Germany it is a well-developed phase of the industry with an annual output of 50,000 tons. The properties of flooring gypsum (called in Germany, "Estrich") are wholly different from those of ordinary gypsum mortars. It is slow setting, has hydraulic properties, is nearly as hard as Portland cement and being somewhat resilient will outwear Portland cement as a flooring material. An interesting discussion of flooring gypsum is found in a pamphlet by M. Glasenapp, translated by Dr. W. Michaelis, Jr., published by Cement & Engineering News.

New York (By D. H. Newland).—The gypsum industry as a whole was fairly prosperous in 1913. The market for calcined plasters was active and called for a larger output on the part of the plants in the western district of Monroe and Genesee counties, and there was also a good demand for crushed rock from Portland cement mauufacturers. A very small proportion of the output was used in ground form for agricultural purposes. The total production of rock by the mines and quarries in the state amounted to 532,884 short tons, or 5 per cent. more than was reported for 1912. There have been no new calcining plants completed in the gypsum belt, although construction work on such a plant was started sometime ago by the Delac Gypsum Products Co. at Mumford. The mines and mill of the Akron Gypsum Co., near Akron, Erie County, were idle throughout the year, and the property recently passed into the hands of the Akron Gypsum Products Corporation, of Buffalo, who intend to reopen the mines during the current season. The mill of the Consolidated Wheatland Plaster Co., in the Garbutt district was destroyed by fire. Within the eastern section of the gypsum belt there was a small output of rock which was consumed in Portland cement and agricultural plaster. The largest operator in this region is the Cayuga Gypsum

Co., at Union Springs. The statistics relating to the industry in 1913 follow:

PRODUCTION OF GYPSUM IN NEW YORK.

	1912. (a)		1913.	
	Short Tons.	Value.	Short Tons.	Value.
Total output, crude	506,996	.....	532,884	.....
Sold crude	170,448	$224,704	183,579	265,879
Ground for land plaster	10,498	23,248	8,521	17,807
Wall plaster, etc., made	274,155	993,562	306,206	1,022,457
Total value	.....	$1,241,514	.....	$1,306,143

(a) U. S. Geol. Surv.

Michigan (By. R. A. Smith).—Important commercial deposits of gypsum are known to occur in rocks belonging to the Upper Mississippian and also to the Silurian, especially in those of the Salina. The Mississippian deposits have been extensively developed near Grand Rapids, Kent County; and at Alabaster, Iosco County. The Silurian deposits occur in the vicinity of St. Ignace, Mackinac County, but have not been developed. Drillings indicate that there are also extensive deposits of gypsum in Arenac and southeastern Ogemaw Counties. Gypsum occurs in lenticular beds varying in thickness from a fraction of an inch up to 25 ft. In the Grand Rapids-Grandville district three beds have been worked—an upper 6-ft. usually quarried, a middle 12-ft. both quarried and mined, and a lower 22-ft. bed which is mined. In Iosco and Arenac Counties there are several beds of workable thickness, ranging from 5 ft. to nearly 25 ft. A 23-ft. bed is quarried at Alabaster, but the other beds have not been developed.

Oklahoma (By C. W. Shannon).—At present there are twelve gypsum mills in the state, located as follows: Two at Watonga, and one each at Bickford, Okeene, Southard, Wilson, Ferguson, Okarche, Alva, Rush Springs, Eldorado, and McAlester. The United States Gypsum Co. has three of these mills, one each at Okarche, Southard and Eldorado. The Okarche mill is the oldest mill in the state. The Oriental Plaster Co. of Wichita, Kansas, at present leases two mills in Oklahoma. These are the mills formerly operated by the Monarch Plaster Co. at Watonga, and that of the Southwestern Cement Plaster Co. at Okeene. Both gypsum and gypsite are used.

The American Cement Plaster Co. of Lawrence, Kansas, operates a mill at Watonga, and use both the rock form and gypsite at this plant. A large part of the plaster manufactured is made into partition blocks.

The Roman Nose Gypsum Co. operates a plant at Bickford.

The rock gypsum is the principal form used. A large part of the output is used in the manufacture of partition blocks, and new machinery has been installed for the manufacture of these blocks by a continuous process is used.

The Ruby Stucco Plaster Mill is situated 4 miles west of Ferguson. The Oklahoma Plaster Co. has a mill at Alva. The material used is chiefly a coarsely selinated gypsum. The Oklahoma Gypsum Co. operates a mill at Wilson, or Homestead. This is the only mill in Oklahoma using the continuous calciner process. This mill is a new one and has been in operation only since early in 1913. The Acme Cement Plaster Co. has a new mill located about 4 miles west of Rush Springs, and gypsite is used as raw material. The Elastic Pulp Plaster Co. has a mill at at McAlester. This mill is removed a great distance from the main gypsum field, but the site selection was made because of the nearness of fuel supply, McAlester being in the heart of the coal region. Rock gypsum is the main material used, and is shipped from the quarry in the western part of the state.

Oklahoma's supply of gypsum is inexhaustible, and is easily accessible, and is easily assembled, but since the area is so far removed from the fuel supply it is difficult to bring about a very marked use of the Oklahoma gypsum. Also the distance of the Oklahoma mills from the large trading centers, and the competition of mills more favorably located works a hardship on the Oklahoma producers. For a few years following 1900 the local markets were very active, and the mills being operated at that time made a large production with considerable profit. This encouraged the building of other mills until by 1910, all the mills in the state, with the exception of one or two, had been built. Just about this time the period of great building activity following statehood suffered a cessation, due to a number of causes. Since that time only a few of the mills have been operating to their full capacity, and during the past 2 or 3 years several of the mills have been idle a great part of the time, and the prices received for the manufactured product and the raw plaster have been very low.

Conditions for securing the gypsum in this state are very favorable because of the small amount of material overlying the principal beds.

Of the reports which so far have been returned to us for 1913, three mills report no production, and three of the largest mills in the state report only a little more than half the amount of production and value of products for that given for 1912. During 1912 the total amount of crude gypsum prepared for the market amounted to 135,074. The quantity furnished to Portland cement mills being 12,714 tons; for land plaster 6628 tons, and the total sold crude 17,334 tons. The mixed wall plaster

78,630 tons. As plaster of Paris and other similar products 3820 tons; as stucco plaster 3792.

Colorado (By. R. D. George).—There are two producers of gypsum in this state—The Buckhorn Plaster Co., operating at Buckhorn, near Loveland, Colo., and The Colorado Portland Cement Co. Both companies confine their attention mainly to ordinary hard plaster, but both have placed on the market a substitute for Keene's cement. The figures for the general industry are as follows:

Total tonnage of gypsum quarried	19,767 tons.
Total tonnage calcined	16,843 tons.
Total tonnage of gypsum plaster or hard plaster	13,484 tons.
Total tonnage of gypsum used in Portland cement manufacture	2,924 tons.

A third company began operation at Ruedi, Colo., some years ago, but the product was of an inferior grade, and the plant closed down about 3 years ago.

The gypsum now quarried occurs in the Lykins formation, the lower part of which is of Permian age, the upper part of which may be of Triassic age, but this has not been proved.

Analyses show that the raw material runs from 92 to 99 per cent. hydrous calcium sulphate. In color the gypsum runs from light gray to pure white, but occasional bands of dark gray or yellowish gray material occur.

The gypsum resources of the state are very large on both sides of the range, and the deposits are apparently all of Permian or of Permo-Triassic age. The present industry is confined to the eastern side of the range, but it is reported that preparations are being made for active operations on the western side of the range during 1914.

The gypsum companies manufacture a number of specially named materials in small quantities, but I was unable to get the amounts produced. These include for the Buckhorn Plaster Co., O. K. Plaster Paris, Matchless Plaster Paris, Fibred Cement Plaster, and Land Plaster.

Wyoming (By L. W. Trumbull).—The Acme Cement Plaster Co., The Overland Cement Plaster Co., and the Red Buttes Hard Plaster Co., made a total production of 30,000 tons of Gypsite Cement and 5000 tons of Plaster of Paris.

The only mills are those located near Laramie, Wyoming, and one small plant in Park County, Wyoming. No record of the name of the last plant mentioned has been found.

Washington (By Henry Landes).—To my knowledge there are no deposits of gypsum in Washington. In Tacoma, Washington, there is a company named the Pacific Coast Gypsum Co., who import gypsum from mines in Alaska and mill the same at their plant in Tacoma.

Iowa.—The district about Fort Dodge produced all of Iowa's gypsum

in 1913 as in former years, though a shaft was sunk to a newly found deposit near Ottumwa, and another year may show some production from this field.

The mill of the American Cement Plaster Company burned in 1913, and this company is erecting a fireproof plant of large capacity and with modern equipment, which will be in operation by July, 1914.

The gypsum at Ottumwa was discovered at a depth of 500 ft. while boring for coal. Considerable anhydrite is present and the fitness of the deposit for wall plaster has not yet been demonstrated. Considerable water was encountered in the shaft though not enough to hinder the development of the bed if the quality of the mineral proves satisfactory, either for cement mill use, or for calcining.

List of Gypsum Mills by States

Arizona.—Arizona Gypsum Plaster Company. (Douglas.)

California.—Acme Cement Plaster Company. (Palmdale, Los Angeles.)

Colorado.—Buckhorn Plaster Company. (Buckhorn.) Colorado Portland Cement Company. (Portland.)

Iowa.—American Cement Plaster Company. (Ft. Dodge.) Acme Cement Plaster Company. (Ft. Dodge.) Cardiff Gypsum Plaster Company. (Ft. Dodge.) Plymouth Gypsum Company. (Ft. Dodge.) United States Gypsum Company. (Ft. Dodge.)

Kansas.—American Cement Plaster Co. (Blue Rapids.) Best Bros. Keene's Cement Company. (Medicine Lodge.) United States Gypsum Company. (Blue Rapids, Hope.)

Michigan.—American Cement Plaster Co. (Grand Rapids.) Grand Rapids Plaster Co. (Grand Rapids.) Michigan Gypsum Company. Grand Rapids.) United States Gypsum Company. (Grand Rapids, Alabaster.)

Montana.—United States Gypsum Company. (Great Falls.)

New York.—American Gypsum Company. (Arkon.) Cayuga Gypsum Company. (Union Springs.) Wheatland Plaster Company. (Wheatland.) Empire Gypsum Company. (Garbutt, Wheatland.) Lycoming Plaster Company. (Garbutt.) National Wall Plaster Company. (Oakfield.) United States Gypsum Company. (Oakfield.)

New Mexico.—Acme Cement Plaster Company. (Acme.) Oriental Plaster Company. (Oriental.) Western Clay & Gypsum Company. (Ancho.)

Ohio.—American Gypsum Company. (Port Clinton.) Fishack Gypsum Company. (Gypsum.) Kelly Plaster Company. (Castalia.) United States Gypsum Company. (Gypsum.)

Oklahoma.—Acme Cement Plaster Company. (Marlowe, Cement, Acme.) American Cement Plaster Company. (Watonga.) Oklahoma Gypsum Company. (Wilson Station.) Oriental Plaster Company. (Watonga, O'Keene, Bickford.) Roman Nose Gypsum Company. (Bickford.) United States Gypsum Company. (Elderado, Okarche.)

North Dakota.—Dakota Plaster Company. (Black Hawk.) United States Gypsum Company. (Rapid City.)

Texas.—Acme Cement Plaster Company. (Acme.) American Cement Plaster Company. (Acme.) Texas Cement Plaster Company. (Hamlin.)

Utah.—American Keenes Cement Company. (Sigourd.) Nephi Plaster Company. (Nephi.) Jumbo Plaster & Cement Company. (Sigourd.)

Virginia.—Southern Gypsum Company, Inc. (North Holston.) United States Gypsum Company. (Plasterco.)

Washington.—Pacific Coast Gypsum Company. (Tacoma—Mine in Alaska.)

Wyoming.—Acme Cement Plaster Company. (Laramie.) Red Buttes Hard Plaster Company. (Red Buttes.) Overland Cement Plaster Company. (Laramie.)

Gypsum in Foreign Countries

Canada.—Imports of Canadian gypsum are steadily increasing and this movement has been favored by the gradual reduction of the duty which by the latest tariff legislation was reduced to 10 per cent. advalorem, or about 15 cents per ton on crude gypsum, which is the form in which most of the gypsum enters the country. Most of the Canadian gypsum is mined in Nova Scotia, for importation to New York, Brooklyn and Chester Pennsylvania, where it is calcined for wall-plaster. Plants using Nova Scotia gypsum are:

J. B. King & Co., New York City, with plants at New Brighton and Roslyn, N. Y. Rock Plaster Mfg. Co., Works on New River, N. Y. Keystone Plaster Co., Chester, Pa. Higginson Mfg. Co., Works at Newburgh, N. Y.

About 20,000 tons of Nova Scotia mineral are annually ground at Norfolk for land plaster which is used in the peanut belt.

The Manitoba Plaster Co., has a well-equipped plant in western Canada.

Australia.—The western Australia newspapers announce the discovery of rich deposits of gypsum at Cowcowing Lake. The field is only 5 or 6 miles from a railway and has an area of about 10,000 acres.

Assays of the gypsum made in the Government laboratory show it to be almost pure, as it contains from 76.62 to 81.23 per cent. of calcium sulphate. It makes an excellent pure white plaster of Paris.

PRODUCTION OF CRUDE GYPSUM IN THE PRINCIPAL COUNTRIES. (a)
(In metric tons.)

Year.	Algeria. (b)	Canada.	France. (b)	Germany. (c)		Greece.	India.	United Kingdom.	United States.
				Baden.	Bavaria.				
1898	37,337	198,864	2,115,261	28,037	25,688	83	8,390	199,174	285,644
1899	39,950	221,821	1,807,454	29,419	29,727	81	6,546	215,974	382,891
1900	42,237	228,656	1,774,492	26,381	35,484	129	4,415	211,436	439,265
1901	44,025	266,476	2,385,633	28,183	3,581	671	(d)	204,045	598,529
1902	44,975	301,165	2,185,346	33,150	31,701	*Nil.*	(d)	228,264	740,906
1903	41,550	285,242	1,998,804	29,423	30,894	94	(d)	223,426	945,285
1904	48,375	309,133	1,957,802	26,984	22,766	393	3,937	237,749	853,546
1905	34,743	395,341	1,378,145	28,823	46,247	185	4,877	259,596	982,626
1906	27,950	378,904	1,377,429	25,643	50,763	70	(e) 5,000	228,627	1,397,480
1907	26,400	431,286	1,316,567	29,153	48,975	70	(e) 5,000	239,285	1,564,061
1908	25,500	346,436	1,750,562	35,217	51,314	*Nil.*	(e) 5,000	231,980	1,694,155
1909	36,250	398,290	1,655,672	36,621	51,630	191	(e) 5,000	242,832	(f)2,042,286
1910	60,625	481,941	1,980,804	41,078	54,397	249	6,678	259,648	(f)2,158,756
1911	61,502	470,381	2,110,520	42,408	60,390	1,263	9,340	281,111	(f)2,112,770
1912	(d)	523,114	2,150,900	51,777	57,114	127	21,369	(e)293,200	(f)2,269,290
1913	.....	580,206	.....	49,767	.....	.....	.....	.....	(f)2,357,752

(a) From official reports of the respective countries, except the statistics for the United States. (b) A part of the product is reported as plaster of Paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (c) Prussia is a large producer of gypsum, but there are no complete statistics available. The output in 1910 was 22,042 tons. (d) Statistics not yet available. (e) Estimated. (f) U. S. Geol. Surv.

IRON AND STEEL

Probably never before has the iron and steel trade experienced such a complete change in the same length of time as has been experienced during 1913, except in years of financial panic. The characteristics of the year were: first, excessive demand in the first 3 or 4 months; second, continuance of a high rate of production for at least 6 months after buying had been sharply checked; third, tremendous shrinkage in production in November and December.

The railroads contributed largely to the prosperity of the iron trade in the early months of 1913. They had placed heavy orders late in 1912 and the resultant demand for steel came on top of a large consumption by the other manufacturers of iron and steel in finished forms. So great was the demand for all classes of steel that the largest steel makers were loaded with contracts, the fulfilment of which would run well into the year. Premiums were readily obtained by those manufacturers who were ready to slip in an occasional order for early delivery. The work of the finished material mills was crowded to such an extent that the supply of semi-finished steel fell considerably short of the demand and mill operations were checked from time to time on that account. Even the largest mills of the United States Steel Corporation were unable to produce sufficient steel to satisfy their requirements and were obliged to buy billets and sheet-bars from outside manufacturers. As a result of this pressure for semi-finished steel, the construction of some 3,000,000 tons of new open-hearth steel capacity was being rushed through, although but a year before it was thought that the existing capacity was in excess of any probable demand.

The enormous demand for steel products was responsible for the great activity of the blast-furnaces. The production of pig iron, which had been steadily growing since July, 1911, culminated in February, 1913, when pig iron was being turned out at the rate of over 34,000,000 tons a year. Although the impulse was checked at this time, the supply having outreached the demand, the momentum of the former activity prevented a serious disturbance for some time, but during the last third of the year a rapid decline was experienced. Steel prices steadily sagged, but pig iron maintained its strength under the influence of the previous buying until September. In October, when the new tariff act went into

effect, complaints of slackening business were heard in every direction. The decline of business was heavy in November; pig-iron prices fell steadily and numerous furnaces were blown out. The operations of the steel works were greatly restricted, numerous plants running only on part time. At the beginning of December the rate of production of pig iron had declined to 26,500,000 tons a year, and the production of steel ingots was estimated to be about 50 per cent. of the steel-making capacity of the country.[1]

Iron Ore

Minnesota:—(By L. O. Kellogg.)[2] Iron-ore shipment figures for 1913 from the Lake Superior ranges fell only a few thousand tons short of the 50,000,000 tons hoped for at the beginning of the season, being the greatest year in the history of the industry.

The Mesabi.—The year on the Mesabi was marked by heavy production and vigorous development; shipments for the range were a record. The entrance of the Longyear interests into the mining field was noted last year; 1913 saw their first shipments from the Bennett mine, the ore being hoisted through the timber shaft. The mine is being stripped and also prepared for underground mining. Of work begun in 1913, that of Jones & Laughlin near Grand Rapids aroused the greatest interest. The company is sinking and drifting for exploration purposes at the Buckeye and Fargo properties between Grand Rapids and Coleraine. It is also experimenting with a small suction dredge in stripping some land to the northwest of Grand Rapids. The use of the dredge is an attempt to find a stripping method cheaper than steam shoveling and its success will determine whether the option is to be exercised. Mining operations at Grand Rapids will be the most westerly on the range. Jones & Laughlin also almost finished the stripping at the Longyear pit near Hibbing, which will be able to ship 500,000 tons in 1914.

The Arthur Iron Mining Co., the operating company for the Great Northern ore holdings, was extremely active. The Smith mine was stripped so as to permit shipping if it had been desired. Two shovels were at work stripping the Dean and four on the Dunwoody. At the Hill Annex, the shaft is probably completed and a surface plant is being erected. The shaft is merely preliminary to stripping operations, as the property will be operated as an open pit. The Judd mine of the Oliver Co. near Coleraine shipped about 100,000 tons in 1913. Near Nashwauk, the Quinn is being stripped by Butler Bros., working on their own account. Unusual interest attaches to this operation, as

[1] Abstracted from *Iron Age*, Jan. 1, 1914.
[2] *Eng. Min. Jour.*, Jan. 10, 1914.

marking the entrance into mining of this firm hitherto engaged only in contract stripping.

The Oliver Co. at the Leonard mine carried on what may be termed intensive mining in the effort to obtain all available ore before the expiration of the Hill lease. The practice, unusual on the range, of stockpiling from an open pit, was begun at the close of the shipping season at this mine as well as at the Alpena. The latter, although not a Hill property, is also held under a short-time lease. The Leonard stockpile must be shipped before the close of the 1914 season; the Alpena can be left indefinitely, as the ore is weighed and royalty paid before stocking. Near Virginia, the Allan mine shipped for the first time in 1913. The royalties paid here were a record for the Mesabi, the commonly stated figure being $1.35. Near Eveleth, the Morrow made substantial shipments and the year saw the first shipments also from the Leonidas, held by the Oliver.

This company is sinking five new shafts this winter, two at the Wanless near Buhl, one at the Philbin near Hibbing, one at the Minnewas between Eveleth and Virginia and one at the Section 27 near Chisholm. These shafts in shape, dimension and lining and in much of their surface equipment will be similar or identical and of a high class. West of Biwabik the Oliver prosecuted vigorous drilling on the Higgins property. It is not likely, however, that this means immediate mining operations. The work was rather in the nature of a thorough exploration preliminary to a readjustment of the terms on which the property is held. Near Mesaba, the Vivian and the Graham came into the shipping class, the former, an underground property, shipped 10,000 tons and the latter, 100,000 tons from one of its open pits. Development is continuing on the former, and development, construction and stripping on the latter. To the west a few miles, the Weed is being developed.

The year saw a certain number of properties closed down, among which may be mentioned the Madrid and Madera. The Inland Steel gave up its lease on the Grace. The flooding of the Euclid probably marks the end of that mine. The Gilbert of the Oliver, was largely dismantled.

The Cuyuna.—First place in interest for 1913 was held by the Cuyuna range. Shipments for the year nearly tripled and it is believed that they will triple again in 1914. While the area of the district was not definitely extended, much new ore was developed within the old boundaries. Additional ore was found near bodies already known, as in Sec. 22–27 and 32–33, T. 47, R. 29, in Sec. 18, T. 46, R. 29, and north of the Armour No. 1. New discoveries include the E. J. Longyear ore-body on Sec. 13, T. 45, R. 30, and additional bessemer ore on the S E 1/4 of the

S W 1/4 of Sec. 1, T. 46, R. 29; in the latter discovery, one hole averaged close to 67 per cent. iron and 0.02 per cent. phosphorus.

During the year, the Pennington, Cuyuna-Duluth and Barrows came into the shipping class, the latter of special interest as being the first shipper from the south range division, the former important as marking the success of the steam-shovel method in the district. The Adams and Mounain Iron are practically ready to ship at the end of the year, and should make a substantial production in 1914. The Rowe should also be a 1914 shipper. The Brainerd-Cuyuna and Brainerd-Duluth began sinking during the year and stripping at the Pennington and Rowe got fairly under way only in 1913. The Inland Steel Co. began stripping the Thompson and should be able to ship from the pit in 1914.

The prevailing faith that the ore will eventually be found to extend to considerable depth was reinforced by the fact that ore was found at 1017 ft. in a hole of the Carlson Exploration Co. east of the Rowe mine. It is generally held that the north range bodies go deeper than those on the south range. A fair but conservative estimate of the tonnage now shown up, would be 200,000,000 to 225,000,000 tons with from 50,000,000 to 100,000,000 more strongly indicated. These figures will, in all likelihood, be greatly increased when the range is finally proved up, as large areas remain to be drilled.

The year saw a marked tendency to change over from underground operations to steam shoveling. While the nature of the occurrence of the ore-bodies is not ideal for open-cut work, the overburden can be handled at an extremely low cost, as has been proved at the Pennington and Rowe mines. The operators, with experience on the other ranges behind them, are following progressive and highly developed methods. Well-built plants are the rule and operations are scientifically conducted.

The question of beneficiation is occupying the attention of many of the companies. The problem is not so simple as on the western Mesabi, as the easily separated sandy ores are not found here. It is likely that any solution of the water-treatment problem will involve the use of tables, jigs or other apparatus and that the methods will vary with every ore. It is stated that the Rowe mine will erect a concentrator next year, using jigs. Work on the Jones step-process plant at Aitken was unfortunately discontinued late in the year on account of a lack of funds. The question of the ultimate value of the manganese present in many of the Cuyuna ores is still undecided, although it is a noteworthy fact that the Cuyuna-Mille Lacs disposed of about 35,000 tons of ore with a low or medium manganese content. A most perplexing question is the payment of royalties for the manganese. A great deal of railroad extension took place in the year and the rivalry for traffic between the Soo and the North-

ern Pacific was strong. The former handled about 85 per cent. of the ore, but the aggressive policy of the Northern Pacific in building, leasing and subleasing will probably serve to reverse this situation eventually. The Soo now enters Riverton and is working toward the Iron Mountain. The Northern Pacific has a spur to Ironton and is getting ready to build to the Duluth-Brainerd; it is reported that it is building to the Kennedy and this is held to indicate that it has bought an interest in the Kennedy fee. The fact that Jones & Laughlin took over on option a Northern Pacific lease on land south and west of the Pennington, is significant as marking the entrance of new operators on the range.

The Vermilion.—There were no great changes on the Vermilion range in 1913. The Oliver mines continued to be the backbone of the camp. The Section 30 made substantial shipments beside adding greatly to its reserves. Development work by outside interests was carried on at Tower and between Tower and Ely some rather important drilling was done. The Sibley mine of the Oliver will probably raise a new inclined shaft in rock in 1914. If present plans are carried out, this shaft will be raised its full section at one operation and the permanent steel sets will be placed as the work progresses. A headframe, a unique piece of construction, is giving excellent service since its erection and it is believed that the difficulties experienced with the moving hanging wall are overcome.

The Gogebic.—The Gogebic range had a successful season in 1913, although not quite equaling its record for shipments. The Ashland was worked intermittently by the fee owners. The Oliver Co. gave up its lease on the Atlantic group in Wisconsin, having failed to find any commercial ore after extensive drilling. The Newport Co. engaged in an elaborate campaign of improvements and reconstruction at its Newport mine, and its Anvil and Palms shafts.

Without doubt the most interesting development of the year was the beginning of operations at the Wakefield mine by M. A. Hanna & Co. The discovery of this large ore-body on the southern edge of the Wakefield bulge in the ore formation, distant from the string of mines along the north edge, was a personal triumph for R. S. Rose, whose belief in the existence of the ore was responsible for bringing in the Hanna Co. to drill. The property is being opened with two shafts, one of them a drop shaft, and is also being partly stripped. A large percentage of the ore is available for steam-shovel mining and the mine, thus opened, will be the first steam-shovel open pit of importance on the old ranges. A fair shipment was made this year.

Iron River and Crystal Falls.—The Iron River and Crystal Falls districts taken together were the equal of the Cuyuna in the importance of

their new development. Among new shippers are the Ravenna, the Courtland, and the Forbes. A great deal of development and construction was done in 1913, as at the Carpenter, the Tully, the Bengal and the Homer, as well as others. The complete and well designed electrical equipment of the Bengal is of interest as being the most elaborate yet installed in the region. At the Tully, the new drop shaft is nearly landed. The active development work on the Mastodon find of the E. J. Longyear Co. was noteworthy. Pickands-Mather, as the Balkan Co., will mine part of this ore. A shaft was dropped to rock, and underground work as well as surface construction is being pushed. It is practically settled that the property will be stripped and mined by steam-shovel methods, the first of the kind in the Menominee region and, except the Wakefield, the only one in Michigan. The Judson, of the Longyear interests, sank a large inclined shaft in rock and will be a shipper in 1914. It will be an underground property and is to have an excellent equipment, largely electrical. The discoveries of the Cleveland-Cliffs and Oliver Cos. north of the Mastodon are important.

During the year, the Oliver Co. gave up operations at the Mansfield and Michigan. Work on the Hollister and Groveland was abandoned; Corrigan & McKinney closed the Great Western, pulled the pumps at the Tobin and gave up the lease on the Crystal Falls.

An important feature of practice in the region is the use of purchased electrical power by many companies. The Peninsular Power Co. intends to add to its hydro-electric plant on the Menominee River and to its steam plant at Iron River so as to double its capacity for 1914. The company sells chiefly in the Iron River district, but is building a line into the Mastodon district to supply the Judson mine. In this particular the region is far in advance of any other range; there is no power sold anywhere else except in small amount in the Cuyuna. The Northwestern road now has a branch into the Mastodon district and the St. Paul branch to Iron River is almost completed. The latter road will be a strong competitor of the Northwestern for business hereafter.

The Menominee Range.—On the Menominee range proper work progressed about as usual. The most important undertaking is that of the Oliver Co. involving the construction of a hydro-electric plant, the relining of the Chapin shaft and the installation of electric pumps in the mine. The work will probably be completed for the 1914 season.

The Marquette District.—The Marquette maintained its preëminence among the old ranges for 1913, although there were no significant developments. Work on the Athens was begun and the shaft is now in rock. An elaborate surface plant is being erected. The Breitung Hematite is sinking a new shaft. Jones & Laughlin drilled extensively west of Ish-

peming, and are sinking south of Lake Sally. The Lake Angeline has probably shipped about its last ore.

In the Cascade district, the Volunteer did some drilling and the Cascade Mining Co., of the Longyear interests, sank its large Isabella shaft. This mine has been excellently handled, and will be developed into a most important property. At Republic, there were no changes of importance except some new construction. The 1913 shipments from the Republic mine were about 140,000 tons.

In the Gwinn district, the close of 1913 saw the Stegmiller and the Stephenson hoisting, and the Gwinn, Mackinac and Gardner equipping.

PRODUCTION OF IRON ORE IN LAKE SUPERIOR DISTRICT.
(In tons of 2240 lb.).

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.
1855...	1,449	1880..	1,948,334	1902..	27,562,566	1907..	42,266,668	1912..	48,211,778
1860...	114,401	1885..	2,466,642	1903..	24,289,674	1908..	26,014,987	1913..	49,947,116
1865...	193,758	1890..	9,003,725	1904..	21,822,839	1909..	42,586,869	.....	.....
1870...	859,507	1895..	10,429,037	1905..	34,353,456	1910..	43,442,397	.....	.....
1875...	881,166	1900..	19,059,393	1906..	38,522,239	1911..	32,793,120	.....	.....

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR DISTRICTS.
(In tons of 2240 lb.)

Range.	1908.	1909.	1910.	1911.	1912.	1913.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Marquette.....	2,414,632	4,256,172	4,392,726	2,833,116	4,202,308	3,966,680
Menominee.....	2,679,156	4,875,385	4,237,738	2,911,174	4,711,440	4,965,604
Gogebic.....	2,699,856	4,088,057	4,315,314	2,603,318	4,996,498	4,531,558
Vermillion.....	841,544	1,108,215	1,203,177	1,088,930	1,844,981	1,566,600
Mesabi.....	17,257,350	28,176,281	29,201,760	22,093,532	32,047,409	34,038,643
Baraboo.....	122,449	82,759	91,682	115,629	104,031	145,010
Cuyuna.....	.....	.....	.....	147,431	305,111	733,021
Total.....	26,014,987	42,586,869	43,442,397	32,793,130	48,211,778	49,947,116

Pennsylvania.[1]—The E. & G. Brooke Iron Co., Birdsboro, Pa., reopened the French Creek mine at St. Peters, Chester County, Pa., which formerly was operated by the same company. Ore has not been taken from this mine since 1898. The property then was shut down due to the fact that it was difficult to roast and its sulphur content made it impracticable to work it in a blast furnace, especially when compared with the good ores tht then were sold in the eastern market at much lower prices than have since been obtainable. A modern plant now has been installed for the desulphurization of the ore. The mineral is crushed and rolled to 1/4-in. size and under and then is passed over a Dwight & Lloyd sintering machine, which brings the sulphur down to below 0.15 and produces a satisfactory product for furnace use. In its natural state, the ore runs 55 per cent. iron, 0.03 phosphorus and about 2.50 sulphur.

[1] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914.

Texas.[1]—The year saw the first activity in shipments to the eastern market from the brown hematite deposits in eastern Texas. Two cargoes totaling about 5000 tons of ore from the properties of the East Texas Brown Ore Development Co., in Cass County, Texas, were shipped to eastern Pennsylvania furnaces during the year. Analyses of this ore showed when dried, 57 per cent. iron, 4.46 silica, 2.37 alumina, 0.170 manganese, 0.103 sulphur and 0.100 phosphorus. The company plans the installation of a crushing and washing plant and some other improvements, but it is not expected that until these are completed it will be an active shipper to the eastern market.

New York.[2]—New York state long has been known to possess some very large bodies of titaniferous iron ore, the commercial development of which has been blocked by the lack of knowledge of the qualities in pig iron due to the titanium constituent and also of expert skill in the smelting of such mineral. To determine fully the exact worth of these deposits to the iron trade, the McIntyre Iron Co., controlling large bodies of titaniferous iron ores in the Lake Sanford district in Essex County, New York state, now is engaged in an exhaustive series of original experiments with the smelting of ore of this character. If the experiments prove successful in demonstrating the value of titaniferous iron ores in furnace mixtures, active development of the Lake Sanford property by the McIntyre Iron Co. promises to follow. Drill holes have been sunk upon the Lake Sanford properties to a depth of 800 ft. and still were in ore. The deposits controlled by the McIntyre Co. are known as Sanford Hill, Iron Mountain, Mill Pond and Cheny. A concentrating plant to have a capacity of 600 tons a day now is in the course of erection at the foot of Sanford Hill. Surveys for a railroad from the mines to Fort Ticonderoga on Lake Champlain have been made and the McIntyre Co. has acquired a large property on Lake Champlain for terminal and dock facilities. Typical analyses of the ore from the Lake Sanford district show approximately 53 per cent. in metallic iron, 0.006 in phosphorus and 17 per cent. in titaniferous oxide in the crude and 56 per cent. metallic iron, 7.40 per cent. titanium and 0.003 per cent. phosphorus in the concentrates.

In the Ausable district in Clinton County, New York, where Witherbee, Sherman & Co. a few years ago acquired a large acreage of the ore land for future reserves, only the barest prospecting work continues to go forward. The properties held by the company embrace 25,000 acres or more and contain, to all indications a great quantity of ore. During 1913, two or three diamond drills were kept at work upon these deposits

[1] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914.
[2] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914.

and a crew of 30 to 40 men was engaged in making magnetic and other surveys. The drills altogether cut a large quantity of ore, most of which was of concentrating grades, and some of it was exceedingly low in phosphorus.

The general location of the Ausable district is about 40 miles north of Port Henry and a few miles west of Port Kent, N. Y. In character, the ore is practically the same as that in the Port Henry region, consisting of a coarse-grained magnetite. Usually it is of Bessemer quality, and of a favorable character for concentrating.

Had it not been for the falling off of demand during November and December, shipments of crude and concentrated ore from the Port Henry district probably would have shattered all records in 1913. As it was, the combined shipments of Witherbee, Sherman & Co., Inc., of the Port Henry Iron Co., and of the Cheever Iron Ore Co., reached about 700,000 tons. The total production of the district was in excess of 1,000,000 tons. Prices realized by Port Henry producers in 1913 were somewhat better than in the preceding year.

Ore Reserves.[1]—With regard to the iron ore reserves of the United States, there are available a number of different recent estimates, differing little as to the facts of the case, but made on different bases as to grades and commercial conditions. An estimate which was prepared a year or so ago to fit in best with our present purposes. It is as follows:

RESERVE TONNAGES, UNITED STATES

District	Minimum	Maximum
Lake Superior region	2,000,000,000	2,500,000,000
Southern red ores	1,500,000,000	2,000,000,000
Texas brown ores	600,000,000	1,000,000,000
Other southern ores	500,000,000	750,000,000
Northeastern states	300,000,000	600,000,000
Western states	300,000,000	700,000,000
Total U. S.	5,200,000,000	7,550,000,000

To this estimate, as originally made, was added the note that it included only ores of present-day commercial grade such ores as are now used during years of business prosperity. It does not include the enormous reserves of very low-grade red ore in the south, or the low-grade siliceous ores of the Lake region. The minimum figures in each case represent the lowest estimate which anyone, writing to-day, could possibly credit to the various districts. The higher figures represent the tonnages which may be hoped for and are probably the closer to the truth. For the purpose of the present article, the maximum figures may be accepted tentatively. The Texas minimum might be decreased some-

[1] E. C. Eckel, *Iron Tr. Rev.*, Jan. 15, 1914.

what; on the other hand, some of the other southern ore tonnages might be increased.

Imports.[1]—Imports of foreign iron ore to the United States in 1913 equaled the record year 1910 and totaled approximately 2,600,000 tons. The heavy receipts of foreign ore last year were due to the prosperous condition of the eastern iron and steel industry during at least three-quarters of that period. Cuban ore deliveries were very heavy and reached the highest tonnage shipped from that island during any single year in history. Practically two-thirds of the foreign ore received in this country last year was Cuban and approximately 2,000,000 tons of the total was obtained from deposits on the North American continent outside the United States. In 1912, about 1,700,000 tons were obtained from such sources. This left in 1913 almost 600,000 tons of ore, which came from trans-Atlantic countries. This total, while slightly more than the preceding year, still indicates a decreased importance of such ores in the eastern market in recent years. This condition has been brought about by reason of the great distances over which this ore must be transported, rendering the question of freight rates the commanding factor in this traffic, and further because of the better prices open to the miners from European consumers. Imports of trans-Atlantic ores for the next four or five years, at least, promise to be maintained at 500,000 tons or more annually, because of the existence of certain long-term contracts, such as that for Swedish ore made by the Bethlehem Steel Co. This gradual switching of European and African ores from the United States to the more favorable trading opportunities offered the operators by English, German and other foreign buyers, has been one of the conspicuous developments of the eastern ore situation of this country during the past several years.

The total imports in tons of foreign iron ore to the United States by principal sources in 1913, as obtained from port receipts and from original sources, is as follows:

Cuba	1,635,622
Sweden	356,074
Newfoundland	213,468
Spain	112,580
Canada	179,901
Venesuela, Africa, and scattering	97,181
Total	2,594,826

As usual, Philadelphia, was the port of largest receipts of foreign ore in 1913, with Baltimore as a good second. The Philadelphia imports were made up from miscellaneous sources, while all the tonnage received at Baltimore was from Cuba. The ore receipts in tons at the different ports during the past year, are reported as follows:

[1] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 191[illegible].

Philadelphia	1,375,000
Baltimore	1,075,000
New York	18,000
Buffalo	5,000
Cleveland	2,000
Total	2,475,000

Iron and Steel Markets

Pittsburgh (By B. E. V. Luty).[1]—In 1913 was witnessed a complete reversal of the trend of 1912. While in 1912 the iron and steel market strengthened almost continuously, in 1913 the market weakened almost continuously.

While the movements in pig iron and in finished-steel products, respectively, were similar in general character, they were different in detail. The divergence was due to the differing natures of the two markets. Pig iron furnishes a strictly open market, with different prices quoted in different districts, and in pig iron a sale is a sale, delivery and acceptance of the material to occur whether the market advances or declines. In steel products, while there is no agreement, expressed or implied, there is a common basis for almost the entire country, delivered prices being a Pittsburgh base price, plus freight from Pittsburgh. In the case of a majority of the sales, if the market declines before delivery the buyer refuses to permit shipment to be made. The fact of the market price being usually well established, since nearly the whole country is on a common basis, tends to deter mills from cutting prices, while a further deterrent influence is found in the fact that a general market decline will impair the validity of contracts already on books. As a rule, therefore, the steel mills do not cut established prices so long as they have enough specifications coming in to operate full, even though further bookings for forward delivery become light.

On account of these conditions the weaker position of the general market which became apparent about the first of the year resulted in an early decline in pig iron, whereas the majority of steel products did not begin to decline until August. During the first seven months of the year pig iron fell off in price a total of about $3 per ton, averaging different grades of pig iron in different markets.

During this period steel-price declines were inconsequential, occurring in no important lines except wire products and sheets. The reduction in pig iron was so extreme, and consumers were so well out of pig iron by midsummer, that a mild buying movement occurred chiefly in June and July, stiffening the market to such an extent that in August and September there was a definite though slight advancing tendency. By the beginning of August some of the Eastern steel mills began to run out of orders and they began to cut prices, particularly on plates.

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

AVERAGE PRICES AT PITTSBURGH, 1913.

	Pig Iron.			Steel.						Nails.	
	Bessemer.	Basic.	No. 2 Foundry.	Ferromanganese.	Bessemer Billets.	Beams	Plates.	Bars.	Black Sheets No. 28.	Wire per Keg.	Cut per Keg.
January	$18.15	$17.35	$18.40	$67.16	$29.00	1.50c	1.50c	1.40c	2.32c	$1.75	$1.70
February	18.15	17.22	18.02	67.16	28.40	1.45	1.45	1.40	2.35	1.75	1.70
March	18.15	16.96	17.50	66.16	29.00	1.45	1.45	1.40	2.35	1.76	1.70
April	17.91	16.61	16.56	63.16	27.50	1.45	1.45	1.40	2.35	1.80	1.70
May	17.68	15.80	15.63	63.16	27.00	1.45	1.45	1.40	2.35	1.80	1.70
June	17.14	15.40	15.08	63.16	26.50	1.45	1.45	1.40	2.29	1.75	1.70
July	16.31	15.13	14.78	61.16	26.50	1.45	1.45	1.40	2.25	1.70	1.70
August	16.56	14.95	14.84	58.86	25.75	1.45	1.44	1.40	2.20	1.67	1.60
September	16.65	15.04	14.90	56.66	24.00	1.40	1.40	1.40	2.12	1.63	1.60
October	16.60	14.61	14.73	52.44	22.50	1.39	1.36	1.39	2.04	1.60	1.60
November	16.03	13.91	14.47	52.16	20.50	1.34	1.29	1.30	1.98	1.60	1.60
December	15.90	13.65	14.40	49.16	20.00	1.25	1.20	1.20	1.90	1.55	1.60
Year	17.10	15.55	15.78	60.03	25.55	1.42	1.41	1.37	2.21	1.70	1.66
Year 1912.	15.99	14.90	15.16	52.35	22.37	1.30	1.30	1.25	2.00	1.64	1.58

Prices of pig iron, ferromanganese and billets are per ton, 2240 lb.; of steel products, per lb.; of nails, per keg of 100 lb., base.

Soon afterward the larger mills in the Central West began to require additional tonnage and they joined in the cutting, whereby in September there was a slight decline and in October and November the declining tendency was quite marked. In October pig iron resumed its declining, soon reaching a lower point than that of midsummer. By the beginning of December pig iron was at a very low level, below the cost line of many furnaces, while steel products, though well above the cost line, were at what was considered a low level. As a consequence of the near approach to the cost line, both pig iron and steel products fell off but slightly in December.

The year's decline in pig iron averaged about $3.50 per gross ton, thus almost balancing the advance which occurred in 1912 and leaving prices within 50 cents of the low point of late 1911, which was the lowest point in pig iron since 1904, 9 years ago.

The year's decline in steel prices averaged about $4.50 per net, or $5 per gross ton, leaving prices an average of about $2 a ton above the low level of late 1911, which was the lowest average level since early 1899, more than 12 years ago.

Pig-iron production by the merchant furnaces reached a maximum early in the year, declining with considerable steadiness thereafter. Activity at the steel works showed little variation during the first half of the year, being practically at capacity, except for a few bessemer-steel departments. In July, August and September the mills turned out about 90 per cent. of their full rated tonnage, while during October and November there was a sharp drop, to about 50 per cent., this rate being

practically maintained during December, except that there were some important closings of works over the holidays.

Chicago (By O. J. Abell[1]).—In the first 2 months of the year the urgency and pressure of buying showed few signs of abating, but as early as March the changing outlook began to be apparent. But it was not until the first half of the year had passed that the real trend of the market became obvious. This was due to the unprecedented anticipation of requirements by the railroad and other users of steel.

Structural shapes and plates at 1.63 cents, Chicago, and steel bars at 1.58 cents were subjected to practically no concessions until October, and even then the decline to the closing prices of the year, 1.38 cents was most gradual. However satisfactory the year may have been to the makers of steel bars, it was even more profitable to the bar-iron mills at Chicago. Except during the period of premium prices which held for steel and iron lasted until mid-summer, the price of bar-iron itself did not achieve an unusual record.

The value of scrap remained so consistently throughout the year without apparent benefit from the prosperous condition of the finished material market that at no time did the price of rolling mill scrap exceed 40 per cent. of the price of bar-iron, while the ratio at times dropped as low as 35 per cent. The abundance of scrap also resulted in numerous economies in handling and carrying charges, which further enhanced the price of bar-iron operations. More scrap has been offered for sale than the market could readily absorb. At Chicago the large accumulation of scrap by one of the railroads had a distinctively depressing influence on the local market. To many who have followed the market, the past year has seemed to inaugurate a readjustment of scrap values on a lower level.

To the producers of pig iron, the market was hardly satisfactory at any time. The highest prices for local foundry iron during 1913 merely reached the average level for the past decade, and one need look no farther than the record of idle furnace capacity to appreciate this situation. With the increase in business in the latter part of 1912 and the advance in price to $18, most of the idle furnace capacity came into production, but almost immediately after the first of the year the market again began to sag and the production was reduced. During the last half of the year the capacity of the idle furnaces was about the same as the previous year.

Southern iron in this market was featureless throughout the year, but an unusually heavy liquidation of stocks brought an interesting period of low prices for charcoal iron during August. Prices as low as $12.50 for large tonnages and $13 for small lots, f.o.b. furnace, were made. During the past few years, in which much progress has been made in the

[1] Abstracted from *Iron Age*, Jan. 1, 1914.

knowledge of foundry manufactures, the market in which charcoal iron could continue to command the customary premium of $2 over coke iron has narrowed appreciably. Failure to meet this situation resulted in the accumulation of huge stocks of charcoal iron in Michigan, and with the awakening came the realization that the iron could be moved only by underselling foundry and malleable irons. During August the average price of charcoal iron at Chicago was $14.69 as compared with $15 for Northern coke iron. This compared with an average price for charcoal iron over the last 13 years of $19.85. During that same period charcoal iron commanded an average premium of $1.83 over coke iron.

While the year just ended has been of declining activity and has brought us as its close into what are called hard times, it has been a year of record breaking profits for the makers of steel products. It has been a year when manufacturers and merchants have been able to establish new outposts in their business. No better example of this can be suggested than the wonderful growth of the business of the jobbers of iron and steel and during the period when mill deliveries were most delayed.

IRON AND STEEL PRICES IN CHICAGO.

Material.	1911.		1912.		1913.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Lake Superior Charcoal.....	$18.50	$16.50	$19.75	$15.75	$18.50	$14.69
Northern No. 2 Foundry.....	16.50	14.00	18.25	14.00	17.90	14.50
Southern No. 2 Foundry.....	15.85	14.35	18.85	14.35	18.15	14.45
Bar Iron.....	1.35c.	1.15c.	1.60c.	1.15c.	1.59c.	1.13c.
Structural Material(a).....	1.63c.	1.30c.	1.83c.	1.25c.	1.63c.	1.41c.

(a) Beams and channels, 3 in. to 15 in., and angles 3 in. to 6 1/4 in. or heavier.

Pig Iron[1]

In 1913 there were 21 states which made pig iron, against 20 states in 1912. The total production of all kinds of pig iron in 1913 amounted to 30,966,301 gross tons, against 29,726,937 tons in 1912, an increase of 1,239,364 tons, or over 4.16 percent. The production in 1913 was the largest in any calendar year in our history. Combining the output in the first six months of 1913 with the output in the last six months of 1912, however, a total is reached for the twelve consecutive months of 32,143,265 tons, or 1,176,964 tons more than in the calendar year 1913. As compared with the output in the last six months of 1909 and the first six months of 1910, the two consecutive half years of next largest production, when 29,751,863 tons were made, an increase is shown in the 1912–13 period over the 1909–10 period of 2,391,402 tons.

[1] Abstracted from Statistical Bulletins of the American Iron and Steel Institute.

PIG-IRON PRODUCTION FOR 100 YEARS.

1820.....	20,000	1859.....	750,650	1878.....	2,301,215	1897.....	9,652,680
1828.....	130,000	1860.....	821,223	1879.....	2,741,853	1898.....	11,773,934
1829.....	142,000	1861.....	653,164	1880.....	3,835,191	1899.....	13,620,703
1830.....	165,000	1862.....	703,270	1881.....	4,144,254	1900.....	13,789,242
1831.....	191,000	1863.....	846,075	1882.....	4,623,323	1901.....	15,878,354
1832.....	200,000	1864.....	1,014,282	1883.....	4,595,510	1902.....	17,821,307
1840.....	286,903	1865.....	831,770	1884.....	4,097,868	1903.....	18,009,252
1842.....	215,000	1866.....	1,205,663	1885.....	4,044,526	1904.....	16,497,033
1846.....	765,000	1867.....	1,305,023	1886.....	5,683,329	1905.....	22,992,380
1847.....	800,000	1868.....	1,431,250	1887.....	6,417,148	1906.....	25,307,191
1848.....	800,000	1869.....	1,711,287	1888.....	6,489,738	1907.....	25,781,361
1849.....	650,000	1870.....	1,665,179	1889.....	7,603,642	1908.....	15,936,018
1850.....	563,755	1871.....	1,706,793	1890.....	9,202,703	1909.....	25,795,471
1852.....	500,000	1872.....	2,548,713	1891.....	8,279,870	1910.....	27,303,567
1854.....	657,337	1873.....	2,560,963	1892.....	9,157,000	1911.....	23,649,547
1855.....	700,159	1874.....	2,401,262	1893.....	7,124,502	1912.....	29,726,937
1856.....	788,515	1875.....	2,023,733	1894.....	6,657,388	1913.....	30,966,301
1857.....	712,640	1876.....	1,868,961	1895.....	9,446,308	.....	.....
1858.....	629,548	1877.....	2,066,594	1896.....	8,623,127	.....	.....

The following table gives the production of pig iron in half-yearly periods from 1908 to 1913, in gross tons. Several thousand tons of ferro-phosphorus, ferro-titanium, ferro-vanadium, and other alloys are included for recent years.

Periods.	1908.	1909.	1910.	1911.	1912.	1913.
First half.....	6,918,004	11,022,346	14,978,738	11,666,996	14,072,274	16,488,602
Second half.....	9,018,014	14,773,125	12,324,829	11,982,551	15,654,663	14,476,699
Total.....	15,936,018	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301

The production in the second half of 1913 shows a decrease of 2,010,903 tons, or almost 12.2 per cent., as compared with the production in the first half of that year. In Pennsylvania the decrease amounted to 815,176 tons, in Ohio to 191,421 tons, in Illinois to 378,057 tons, in Indiana and Michigan to 13,603 tons, in New York and New Jersey to 199,280 tons, and in Alabama to 98,435 tons. With the exception of New Jersey, Kentucky, Michigan, Missouri, and Minnesota no state increased its output of pig iron in the last half of 1913 over its output in the first half for that year.

Georgia, Texas, Oregon, and Washington were the only states having one or more blast-furnaces that did not make pig iron in 1913. California, which does not have a blast-furnace, produced a small tonnage of pig iron in an electric furnace. Georgia last made pig iron in 1911, Washington in 1910, Texas in 1909, and Oregon in 1894. For the first time in over 40 years, and probably for the first time in its history, Mississippi appears in 1913 among the states which made pig iron.

The following table gives the production of pig iron by States.

PRODUCTION OF PIG IRON BY STATES.
(In tons of 2240 lb.).

States.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Massachusetts and Connecticut..	19,119	13,794	18,388	16,582	9,649	17,366	12,810
New York.....	1,659,752	1,019,425	1,733,675	1,938,407	1,562,756	1,939,231	2,187,620
New Jersey.....	373,189	225,372	294,474	264,781	40,663	36,876	
Pennsylvania ...	11,348,549	6,987,191	10,918,824	11,272,323	9,807,073	12,552,131	12,954,940
Maryland.....	411,833	183,502	286,856	326,214	255,816	219,546	289,959
Virginia.....	478,771	320,458	391,134	444,976	293,642	256,167	341,815
Alabama.....	1,686,674	1,397,014	1,763,617	1,939,147	1,712,211	1,862,681	2,057,911
N. Car., Geo. & Texas.....	55,825	24,345	26,072	14,725	1,200	*Nil.*	
West Virginia...	291,066	65,551	228,282	174,661	291,472	274,360	315,731
Kentucky.....	127,946	45,096	86,371	100,509	95,202	68,760	
Tennessee.....	393,106	290,826	333,845	397,569	324,648	338,238	280,541
Ohio.....	5,250,687	2,861,325	5,551,545	5,752,112	5,310,506	6,802,493	7,129,525
Illinois	2,457,768	1,691,944	2,467,155	2,675,646	2,108,002	2,887,359	(a)2,927,977
Michigan.....	(a)436,507	(a)348,096	(a)964,289	(a)1,250,103	1,163,932	(a)1,770,628	1,775,883
Wisconsin & Minn.	322,083	148,938	348,177	307,200	276,807	303,370	367,326
W. of Miss. River	468,486	313,071	382,767	428,612	395,968	397,731	324,263
Total.....	25,781,361	15,936,018	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301

(a) Includes Indiana.

The states which decreased their output of pig iron in 1913 as compared with 1912 were Connecticut, West Virginia, Tennessee, Michigan, Missouri, Colorado, and California.

The production of pig iron from 1907 to 1913, classified according to the fuel used, was as follows.

PIG IRON PRODUCTION ACCORDING TO THE FUEL USED.
(In tons of 2240 lb.)

Fuel Used.	1907.	1908.	1909.	1910.	1911.	1912	1913.
Coke(a).....	23,972,410	15,331,863	24,721,037	26,257,978	23,141,296	29,132,733	30,348,973
Anthracite & coke	1,335,286	318,741	682,383	628,579	212,548	236,467	254,901
Anthracite alone...	36,268	36,268	16,048	20,503	17,027	10,712	22,446
Charcoal.....	(b)437,397	(b)249,146	(b)376,003	396,507	278,676	347,025	339,981
Charcoal & coke..							
Total.....	25,781,361	15,936,018	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301

(a) Under coke furnaces are included the very few which use raw bituminous coal. It may be assumed that 99 per cent. of this class of iron was made with coke. (b) Includes a small quantity made by the electric furnace.

The charcoal figures include small quantities of pig iron made with charcoal and electricity. The totals for each of the years also include small tonnages of ferro-alloys made with electricity, coke and electricity, etc.

Comparing 1913 with 1909, an increase of 5,627,936 tons is shown in the production of pig iron with bituminous fuel and of 6398 tons with anthracite coal alone, while the output of pig iron with anthracite coal and coke mixed shows a decrease of 427,482 tons and with charcoal of 36,022 tons.

The following table gives the number of completed and rebuilding furnaces on December 31 of each year since 1908.

Fuel used—blast furnaces.	1908.	1909.	1910.	1911.	1912.	1913.
Bituminous coal and coke....	365	372	382	385	395	394
Anthracite and anth. and coke	45	48	42	35	26	23
Charcoal.....	49	49	50	45	45	45
Total.....	459	469	474	465	466	462

The following table gives by fuels the number of blast furnaces, which were active during a part or the whole of each half year in 1912 and 1913; also the number idle.

Fuel used—active and idle furnaces.	1912.						1913.					
	First half.			Second half.			First half.			Second half.		
	Active.	Idle.	Total.	Active.	Idle.	Total.	Active.	Idle.	Total.	Active.	Idle.	Total.
Bituminous, chiefly coke.	274	121	395	301	94	395	308	86	394	297	97	394
Anthracite and coke.....	2	20	22	9	13	22	13	8	21	7	14	21
Anthracite alone.....	0	4	4	1	3	4	1	3	4	2	0	2
Charcoal.....	26	19	45	26	19	45	26	19	45	24	21	45
Total.....	302	164	466	337	129	466	348	116	464	330	132	462

On December 31, 1913, there were 3 furnaces in course or erection and 8 were being rebuilt. Of the building furnaces 1 was in Pennsylvania and 2 were in Minnesota. When completed all will use coke for fuel. They will have a total annual capacity of 505,000 gross tons of pig iron.

In 1913 there were 5 entirely new blast furnaces built, 4 coke and 1 charcoal, with an annual capacity of 596,000 gross tons, as follows: Pennsylvania, 2, with an annual capacity of 360,000 tons; Virginia, 1, with an annual capacity of 50,000 tons; Ohio, 1, with an annual capacity of 182,500 tons; and Mississippi, 1 (charcoal), with an annual capacity of 3500 tons. In addition 1 charcoal furnace in Georgia, with an annual capacity of 13,500 tons, was revived.

During 1913 there were 10 blast furnaces abandoned or dismantled, with a total annual capacity of 316,000 gross tons, as follows: New York, 1, with an annual capacity of 30,000 tons; Pennsylvania, 4, with an annual capacity of 76,000 tons; Virginia, 2, with an annual capacity of 50,000 tons; Tennessee, 1, with an annual capacity of 48,000 tons; Ohio, 1, with an annual capacity of 85,000 tons; and Michigan, 1, with an annual capacity of 27,000 tons. When last in blast 2 furnaces, with an annual capacity of 29,000 tons, used charcoal, and 8 furnaces, with an annual

capacity of 287,000 tons, used mineral fuel. Some of these furnaces had been idle for many years.

UNITED STATES EXPORTS OF DOMESTIC IRON AND STEEL.
(In tons of 2240 lb.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Pig iron	83,317	73,844	46,696	61,999	127,385	120,799	272,676	277,648
Billets, blooms, etc.	192,616	79,991	112,177	104,862	58,230	234,267	294,818	91,847
Bars	88,102	98,654	46,103	87,960	125,606	141,033	230,139	288,331
Rails	328,036	338,906	196,510	299,540	353,180	420,874	446,473	460,553
Sheets and plates	110,654	122,696	104,993	180,048	274,516	372,373	546,968	463,247
Structural steel	112,555	138,442	116,878	90,830	146,721	223,493	288,164	416,264
Wire	174,014	161,228	136,167	149,341	171,928	229,316	244,711	190,284
Wire-rods	5,896	10,653	7,412	20,142	22,869	22,641	65,470	61,681
Nails and spikes	59,491	55,826	38,906	48,055	61,201	77,833	92,497	62,724
Pipe and fittings	.....	176,832	114,371	162,140	155,728	197,597	249,856	301,790

UNITED STATES IMPORTS OF IRON AND STEEL.
(In tons of 2240 lb.)

	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Pig iron	212,465	379,828	489,440	92,202	174,988	237,233	148,459	129,325	120,612
Billets, blooms, etc.	14,637	21,337	19,334	12,112	19,913	46,578	29,205	18,702	26,638
Scrap iron and steel	23,731	19,091	27,687	5,090	63,504	72,764	17,272	23,612	37,866
Bars	37,298	35,793	39,746	19,672	19,206	43,692	26,729	26,112	28,243
Rails	17,278	4,943	3,752	1,719	1,513	.....	.....	3,780	10,408
Wire-rods	17,616	17,999	17,076	11,208	10,544	20,374	15,483	15,070	16,098
Tinplates	65,740	56,983	57,773	58,320	62,593	66,640	14,099	2,052	20,685

IRON AND STEEL EXPORTS AND IMPORTS, UNITED STATES.
TOTAL VALUE. (a)

	1908.	1909.	1910.	1911.	1912.	1913.
Exports	$151,113,114	$157,680,331	$201,271,903	$249,656,411	$289,128,420	$294,435,060
Imports	19,957,261	30,571,542	38,907,119	28,995,600	29,328,709	33,601,222
Excess, exports	$131,155,853	$127,108,789	$162,364,784	$220,660,811	$259,799,711	$260,833,838

(a) Including machinery.

STEEL[1]

The production of all kinds of steel ingots and castings in 1913 amounted to 31,300,874 tons, against 31,251,303 tons in 1912. While the production in 1913 was the largest in the country's history, it was only 49,571 tons greater than the output in 1912. Of the total production in 1913, 30,280,130 tons were ingots and 1,020,744 tons were castings, against 30,284,682 tons of ingots and 966,621 tons of castings in 1912.

In 1913 there were 304 works in 30 States, the District of Columbia, and the Canal Zone, Panama, which made steel ingots or castings, as compared with 306 works in 31 States, the District of Columbia, and the Canal Zone, Panama, in 1912.

[1] Abstracted from the Statistical Bulletin of the American Iron and Steel Institute.

STEEL PRODUCTION FOR 13 YEARS.
(In tons of 2240 lb.)

	Acid.								Basic.		Total.
	Converter.		Open-hearth.		Crucible, etc.		Total.		Open-hearth.		
	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.
1901	8,713,302	64.7	1,037,316	7.7	103,984	0.7	9,854,602	73.1	3,618,993	26.9	13,473,595
1902	9,138,363	61.2	1,191,196	8.0	121,158	0.7	10,450,717	69.9	4,496,533	30.1	14,947,250
1903	8,592,829	59.1	1,094,998	7.5	112,238	0.8	9,800,065	67.4	4,734,913	32.6	14,534,978
1904	7,859,140	56.7	801,799	5.8	92,581	0.7	8,755,520	63.2	5,106,367	36.8	13,859,887
1905	10,941,375	54.6	1,155,648	5.8	111,196	0.6	12,208,219	61.0	7,815,728	39.0	20,023,947
1906	12,275,830	52.5	1,321,653	5.6	141,893	0.6	13,739,376	58.7	9,658,760	41.3	23,398,136
1907	11,667,549	49.9	1,269,773	5.5	145,309	0.6	13,082,631	56.0	10,279,315	44.0	23,361,946
1908	6,116,755	43.7	696,304	4.9	69,763	0.5	6,882,634	49.4	7,140,425	50.9	14,023,247
1909	9,330,783	39.0	1,076,464	4.5	130,302	0.5	10,537,549	44.0	13,417,472	56.0	23,955,021
1910	9,412,772	36.1	1,212,180	4.6	177,638	0.7	10,802,599	41.4	15,292,329	58.6	26,094,919
1911	7,947,854	33.6	912,718	3.8	129,602	0.4	8,990,174	37.8	14,685,932	62.2	23,676,106
1912	10,327,901	33.4	1,139,221	3.6	142,679	0.4	11,609,801	37.2	19,641,502	62.8	31,251,303
1913	9,545,706	30.5	1,255,305	4.0	155,237	0.5	10,956,248	35.0	20,344,626	65.0	31,300,874

Included in the total for 1913 are about 714,357 tons of ingots and castings which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, nickel, or other alloys, of which about 625,430 tons were ingots and about 88,927 tons were castings, as compared with about 792,501 tons in 1912, of which about 689,392 tons were ingots and about 103,109 tons were castings. Of the total in 1913 about 74,924 tons were Bessemer steel ingots or castings, about 599,890 tons were open-hearth, about 28,279 tons were crucible, about 11,254 tons were electric, and about 10 tons were miscellaneous.

Steel Ingots.—The total production of all kinds of steel ingots in 1913, not including steel castings, amounted to 30,280,130 tons, against 30,284,692 tons in 1912, a decrease of 4,552 tons. The production in 1912 was the largest in our history. The following table gives the output of all kinds of steel ingots by processes in 1913. Gross tons are used.

States, ingots only, gross tons.	Bessemer ingots.	Open-hearth ingots.	Crucible and all other.	Total ingots gross tons.
Mass., R. I., Conn., N. Y., and N. J.	358,504	1,112,749	38,176	1,509,429
Pennsylvania	2,942,070	12,160,867	70,268	15,173,205
Md., D. of C., W. Va., Ky., Ga., Ala.	628,859	1,163,533	.....	1,792,392
Ohio	4,0.6,664	2,578,295	.....	6,594,959
Indiana, Ill., Col., Utah, and Cal.	1,519,103	3,674,271	16,771	5,210,145
Total for 1913	9,465,200	20,689,715	125,215	30,280,130
Total for 1912	10,259,151	19,909,875	115,656	30,284,682

Steel Castings.—In 1913 the production of all kinds of steel castings amounted to 1,020,744 tons, against 966,621 tons in 1912, an increase of 54,123 tons. The following table gives the production by processes in 1913.

States, castings only, gross tons.	Bessemer castings.	Open-hearth castings.	Crucible and all other.	Total castings.
Mass., Conn., New York, and N. J.	15,344	78,982	3,572	97,898
Pennsylvania	12,748	361,360	6,981	381,089
Del., Md., Dist. of Col., Va., W. Va., Ky., Tenn., Ga., Ala., La., Texas, and Ohio	16,202	168,368	5,455	190,025
Indiana, Illinois, and Michigan	18,588	194,406	6,078	219,072
Wis., Minn., Iowa, Mo., Kan., Col., Utah, Ore., Wash., Cal., and Canal Zone, Panama	17,624	107,100	7,936	132,660
Total for 1913	80,506	910,216	30,022	1,020,744
Total for 1912	68,750	870,848	27,023	966,621

Alloy Treated Steel Ingots and Castings.—The following table gives the approximate production in 1913 by processes of steel ingots and castings which were treated with ferro-vanadium, ferro-titanium, nickel, etc.

Processes, alloy steel, gross tons.	Ingots.	Castings.	Total.
Bessemer steel	53,751	21,173	74,924
Open-hearth steel—acid	153,140	60,264	213,404
Open-hearth steel—basic	382,437	4,049	386,486
Crucible steel	25,281	2,998	28,279
Electric and miscellaneous steel	10,821	443	11,264
Total for 1913	625,430	88,927	714,357
Total for 1912	689,392	103,109	792,501
Total for 1911	425,169	56,290	481,459
Total for 1910	538,462	29,357	567,819
Total for 1909	158,978	23,002	181,980

Open Hearth Steel.—The total production of open-hearth steel ingots and direct castings in 1913 amounted to 21,599,931 tons, against 20,780,723 tons in 1912, an increase of 819,208 tons, or over 3.9 per cent. In 1908 the production of open-hearth steel for the first time exceeded the production of Bessemer steel, the excess amounting to 1,719,974 tons, or over 28.1 per cent. In 1913 the output of open-hearth steel exceeded the output of Bessemer steel by 12, 054,225 tons, or over 126.2 per cent. Of the total production of open-hearth steel in 1913, 20,689,715 tons were ingots and 910,216 tons were castings, against 19,909,875 tons of ingots and 870,848 tons of castings in 1912.

About 599,890 tons of open-hearth steel ingots and direct castings which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, nickel, or other alloys are included in the total for 1913, as compared with about 573,880 tons so included in 1912. Of the total in 1913 about 535,577 tons were ingots and about 64,313 tons were castings, while in 1912 about 493,195 tons were ingots and about 80,685 tons were castings.

In 1913 there were 20,344,626 tons of open-hearth steel made by the basic process and 1,255,305 tons by the acid process, while in 1912 the production by the basic process amounted to 19,641,502 tons and by the acid process to 1,139,221 tons. Included in the total for 1913 are about 386,468 tons of basic and about 231,404 tons of acid open-hearth ingots and castings which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, etc., as compared with about 413,102 tons of basic and about 160,778 tons of acid steel ingots and castings which were similarly treated in 1912.

The following table gives the production by States of both basic and acid open-hearth steel ingots and castings in 1913.

States, basic and acid steel, gross tons.	Basic steel.	Acid steel.	Total.
New England	136,754	58,665	195,419
New York and New Jersey	919,506	76,806	996,312
Pennsylvania	11,578,352	943,875	12,522,227
Ohio	2,680,357	45,862	2,726,219
Indiana	2,116,261	63,845	2,180,106
Illinois	1,251,285	13,569	1,264,854
Ala., Md., Mich., Wis., Dist of Col., etc	1,662,111	52,683	1,714,794
Total for 1913	20,344,626	1,255,305	21,599,931
Total for 1912	19,641,502	1,139,221	20,780,723

At the close of 1913 there were 183 complete open-hearth steel plants, of which 158 were active during the year and 25 were idle. Of the total, 119 were equipped to make basic steel, of which 105 were active during the year and 14 were idle; and 93 were equipped to make acid steel, of which 76 were active and 17 were idle. Some of the plants were equipped to make both basic and acid steel. Seven plants were being built on December 31, 1913, located as follows: Pennsylvania, 1; District of Columbia, 1; Ohio, 3; Indiana, 1; and Minnesota, 1. On the same date work had been suspended upon 1 partly-erected plant. In addition 5 plants were projected, namely, 1 in West Virginia and 4 in Ohio.

At the close of 1912 there were 182 completed open-hearth steel plants, of which 157 were active during the year and 25 were idle. Of the total, 113 were equipped to make basic steel, of which 101 were active during the year and 12 were idle; and 96 were equipped to make acid steel, of which 77 were active in 1912 and 19 were idle. Several plants were equipped to make both basic and acid steel. Six plants were being built on December 31, 1912, located in 4 states. Three of these plants were completed in 1913.

Duplex Steel Ingots and Castings.—Included in the 20,344,626 tons of basic open-hearth steel ingots and castings produced in 1913 are 2,210,718 tons of duplex steel ingots and castings which were made from metal

partly purified in Bessemer converters and finally purified in basic open-hearth steel furnaces, against 1,438,654 tons in 1912, an increase of 772,-064 tons, or over 53.6 per cent. In 1913 duplex steel ingots and castings were produced by 9 works in 5 states, as follows: New York, 1; Pennsylvania, 5; Maryland, 1; Alabama, 1; and Illinois, 1; against 7 works in 4 states in 1912, namely 4 in Pennsylvania, and 1 each in Maryland, Alabama, and Illinois. Acid open-hearth steel was not produced by the duplex process in 1912 or 1913.

Bessemer Steel.—The production of Bessemer steel ingots and castings in 1913 amounted to 9,545,706 tons, against 10,327,901 tons in 1912, a decrease of 782,195 tons. The maximum production was reached in 1906, when the output amounted to 12,275,830 tons. The year of next largest output was 1907. As compared with 1906 the production in 1913 shows a decrease of 2,730,124 tons. In 1913, 9,465,882 gross tons were made by the standard Bessemer process, 42,408 gross tons by the Tropenas process, and 37,416 gross tons by other modifications of the standard Bessemer process.

The following table gives the production by States of Bessemer steel ingots and castings from 1908 to 1913.

States, gross tons.	1908.	1909.	1910.	1911.	1912.	1913.
Ohio	1,955,446	3,466,077	3,314,053	3,268,994	4,285,673	4,024,662
Pennsylvania	2,106,382	2,845,602	2,975,750	2,338,813	3,157,928	2,954,818
Illinois	1,237,747	1,632,444	1,693,053	1,335,053	1,559,576	1,475,274
Other States	817,180	1,386,660	1,429,916	1,004,994	1,324,724	1,090,952
Total	6,116,755	9,330,783	9,412,772	7,947,854	10,327,901	9,545,706

The total production of Bessemer steel ingots and castings in 1913 includes about 74,924 tons which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, nickel, or other alloys, of which about 53,751 tons were ingots and about 21,173 tons were direct castings. In 1912 the total production of alloy-treated Bessemer steel ingots and castings amounted to about 178,241 tons, of which about 159,427 tons were ingots and about 18,814 tons were castings.

On December 31, 1913, 110 plants were equipped to make steel by the standard Bessemer process or some of its modifications, as compared with 102 plants on December 31, 1912, an increase of 8 plants. At the close of 1913 thirty plants were equipped to make steel by the standard Bessemer process, 39 plants by the Tropenas process, and 41 plants by other modifications of the standard Bessemer process, while, at the close of 1912, thirty plants were equipped to make steel by the standard Bessemer process, 35 by the Tropenas process, and 37 by other modifications of the standard

Bessemer process. On December 31, 1913, one small Bessemer steel plant was being built in Pennsylvania; at the close of 1912 no plants were under construction. On December 31, 1913, 8 modified Bessemer plants were projected, as compared with 13 plants on December 31, 1912.

Crucible Steel.—The production of crucible steel in 1913 amounted to 121,226 tons, against 121,517 tons in 1912, a decrease of 291 tons. The maximum production was reached in 1907, when 131,234 tons were made. The year of next largest production was 1906. In the total for 1913 are included about 28,279 tons of crucible steel which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, or other alloys, of which about 25,281 tons were ingots and about 2,998 tons were castings. In 1912 the production of alloy-treated crucible steel amounted to about 30,761 tons, of which about 27,553 tons were ingots and about 3,208 tons were castings.

The total number of completed crucible steel plants in 1913 was 101, of which 82 were active and 19 were idle. On December 31, 1913, 2 plants were being built.

Electric Steel.—The production of steel by the electric process in 1913 amounted to 30,180 tons, as compared with 18,309 tons in 1912, an increase of 11,871 tons, or over 64.8 per cent. The following table gives the production of electric steel ingots and castings since 1909. In 1908 there were 55 tons of electric steel produced, but this tonnage was included with open-hearth steel for that year. Gross tons are used.

Years, electric steel, gross tons.	Ingots.	Castings.	Total.
1909	13,456	306	13,762
1910	50,821	1,320	52,141
1911	27,227	1,878	29,105
1912	14,147	4,162	18,309
1913	20,973	9,207	30,180

In the total production of electric steel in 1913 are included about 11,254 tons of steel ingots and castings which were treated with ferro-vanadium, ferro-titanium, ferro-chrome, etc., of which about 10,821 tons were ingots and about 433 tons were castings. In 1912 the production of similarly treated steel amounted to about 9,609 tons—about 9,217 tons of ingots and about 392 tons of castings.

On December 31, 1913, the number of completed plants which were equipped for the manufacture of steel by the electric process was 19, as compared with 14 plants at the close of 1912, a gain of 5 plants. In addition 3 plants were being built on December 31, 1913—1 in New York, 1 in Pennsylvania, and 1 in Oregon—and 7 plants were projected—1 in New York, 1 in New Jersey, 2 in Pennsylvania, 1 in Tennessee, 1 in Ohio, and 1 in Michigan.

Rails.—The producton of all kinds of rails in 1913 amounted to 3,502,780 tons, against 3,327,915 tons in 1912, an increase of 174,865 tons, or over 5.2 per cent. Included in the total for 1913 are 195,659 tons of girder and high T steel rails for electric and street railways, against 174,004 tons in 1912 and 205,409 tons in 1911. The maximum production of all kinds of rails was reached in 1906, when 3,977,887 tons were rolled, or 475,107 tons more than were produced in 1913.

Of the total production of rails in 1913, 3,303,944 tons were rolled from open-hearth, Bessemer, and electric steel blooms or billets, against 3,165,939 tons in 1912; 43,793 tons were rolled from new seconds, defective new rails, and steel crop ends, against 42,586 tons in 1912; and 155,043 tons were rerolled from old steel rails or were renewed steel rails, against 119,390 tons in 1912. No iron rails were reported for 1912 or 1913.

The production of open-hearth steel rails in 1913 amounted to 2,527,710 tons, against 2,105,144 tons in 1912, an increase of 422,566 tons, or over 20 per cent. Of the total in 1913, 2,514,658 tons were rolled from ingots and 13,052 tons were rolled from new seconds, defective new rails crop ends, etc. Almost all were rolled from basic steel. The maximum production of open-hearth rails was reached in 1913. The year of next largest production was 1912.

The following table gives the production of acid and basic open-hearth rails by states from 1908 to 1913, in gross tons.

States—Gross tons.	1908.	1909.	1910.	1911.	1912.	1913.
N. Y., N. J., and Pa.....	184,059	335,856	445,139	579,924	712,056	924,445
Md., Ala., and Ohio.....	251,956	344,842	570,878	509,950	600,113	743,420
Ind., Ill., Wis., Col., and Cal.	135,776	575,976	735,342	587,049	792,975	859,845
Total.....	571,791	1,256,674	1,751,359	1,676,923	2,105,144	2,527,710

The production of Bessemer steel rails in 1913 amounted to 817,591 tons, against 1,099,926 tons in 1912, a decrease of 282,335 tons, or over 25.6 per cent. Of the total in 1913, 786,850 tons were rolled from ingots and 30,741 tons were rolled from new seconds, defective new rails, crop ends, etc. Pennsylvania was the largest maker of Bessemer rails in 1913, but Illinois was the largest maker in 1908, 1909, 1910, 1911, and 1912. The maximum production of Bessemer rails was reached in 1906, when 3,791,459 tons were produced. Bessemer rails were rolled by 8 works in 5 states in 1913, against 10 works in 7 states in 1912.

The following table gives the production of Bessemer steel rails by states from 1908 to 1913, in gross tons.

States.	1908.	1909.	1910.	1911.	1912.	19
N. Y., N. J., and Md.	386,730	586,193	568,353	284,230	367,128	202,
Pennsylvania	315,547	553,719	591,473	352,331	343,837	326,
West Va., Ala., Ohio, Ind., and Ill.	576,040	627,259	724,616	416,859	388,961	288,
Wis., Col., Cal., and Wash.	70,836					
Total	1,349,153	1,767,171	1,884,442	1,053,420	1,099,926	817,

WEIGHT OF ALL KINDS OF RAILS FROM 1897 TO 1913.

Years—Gross Tons.	Under 45 Lb. per Yard.	45 Lb. and Less than 85.	85 Lb. and Over per Yard.	Tota Gross T
1904	291,883	1,320,677	672,151	2,284,7
1905	228,252	1,601,624	1,546,053	3,375,9
1906	284,612	1,749,650	1,943,625	3,977,8
1907	295,838	1,569,985	1,767,831	3,633,6
1908	183,869	687,632	1,049,514	1,921,0
1909	255,726	1,024,856	1,743,263	3,023,8
1910	260,709	1,275,339	2,099,983	3,636,0
1911	218,758	1,067,696	1,536,336	2,822,7
1912	248,672	1,118,592	1,960,651	3,327,9
1913	*270,405	†967,313	2,265,062	3,502,7

* Include rails under 50 lb. † Include 50 lb. and less than 85 lb.

PRODUCTION OF ALL KINDS OF RAILS.

Years, Rails.	Open-hearth Steel.	Bessemer Steel.	Rerolled Steel.*	Electric Steel.	Iron.	Total
1904	145,883	2,137,957	.....	.....	871	2,284,
1905	183,264	3,192,347	.....	.....	318	3,375
1906	186,413	3,791,459	.....	.....	15	3,977
1907	252,704	3,380,025	.....	.....	925	3,633
1908	571,791	1,349,153	.....	.....	71	1,92
1909	1,256,674	1,767,171	.....	†	.....	3,02
1910	1,751,359	1,884,442	.....	†	230	3,63
1911	1,676,923	1,053,420	91,751	462	234	2,87
1912	2,105,144	1,099,926	119,390	3,455	.....	3,3
1913	2,527,710	817,591	155,043	2,436	.....	3,5

* Rerolled from old steel rails and renewed rails which the manufacturers could not c Bessemer or open-hearth. Included with Bessemer and open-hearth steel rails to 1910. † S nages rolled in 1909 and 1910 but not included with Bessemer and open-hearth rails for thes

Alloy Steel Rails.—Included in the 3,502,780 tons of steel rails r 1913 are 59,519 tons of rails rolled from alloy-treated steel, as co with 149,267 tons in 1912.

The following table gives the production by processes of alloy steel rails since 1909, in gross tons.

Alloy Rails—Gross Tons.	Open-hearth and Electric.	Bessemer.
Titanium steel rails	30,653	17,002
Manganese, copper, and nickel	2,914	8,950
Total for 1913	33,567	25,952
Total for 1912	40,393	108,87
Total for 1911	38,539	115,4
[illegible]	27,389	229,9
[illegible]	13,696	35,4

The following table gives the output by kinds since 1909 of rails rolled from alloy-treated steel.

Alloy Rails—Gross Tons.	1909.	1910.	1911.	1912.	1913.
Titanium steel rails	35,945	256,759	152,990	141,773	47,655
Manganese, copper, nickel, etc.	13,450	565	999	7,494	11,864
Total	49,395	257,324	153,989	149,267	59,519

PRODUCTION OF THE U. S. STEEL CORPORATION.
Including Tennessee C., I., & Ry. Company.

	1908.	1909.	1910.	1911.	1912.	1913.
Iron Ore Mined—	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
From Marquette Range	830,087	899,002	830,094	560,685	551,575	583,266
From Menominee Range	1,021,598	1,359,415	1,386,465	1,105,044	995,401	980,346
From Gogebic Range	1,078,025	1,312,701	1,801,480	1,264,734	1,497,950	1,871,700
From Vermilion Range	927,206	1,066,474	1,338,110	1,182,075	1,301,663	1,301,163
From Mesabi Range	11,272,397	16,968,592	17,910,366	14,581,530	20,001,953	21,634,206
In Southern Region	1,533,402	1,824,863	1,981,301	1,239,563	2,079,907	2,367,770
Total	16,662,715	23,431,047	25,245,816	19,933,631	26,428,449	28,738,451
Coke Manufactured	8,169,931	13,590,112	13,649,578	12,120,212	16,719,387	16,663,480
Coal Mined, not used in making coke	3,008,810	3,089,021	4,850,111	5,290,671	5,905,153	6,705,381
Limestone Quarried	2,186,007	4,715,708	5,005,087	4,835,703	6,124,541	6,338,509
Blast Furnace Products—						
Pig iron	6,810,831	11,436,570	11,645,510	10,593,726	13,990,329	13,879,706
Spiegel	74,716	80,942	102,260	66,435	53,829	65,236
Ferro-manganese and Silicon	48,861	100,838	83,628	84,736	142,006	135,788
Total	6,934,408	11,618,350	11,831,398	10,744,897	14,186,164	14,080,730
Steel Ingot Production—						
Bessemer ingots	4,055,275	5,846,300	5,796,223	5,055,696	6,643,147	6,131,809
Open-hearth ingots	3,783,438	7,508,889	8,383,146	7,697,674	10,258,076	10,524,552
Total	7,838,713	13,355,189	14,179,369	12,753,370	16,901,223	16,656,361
Rolled and Other Finished Products for Sale—						
Steel rails	1,050,389	1,719,486	2,118,473	1,568,028	1,857,407	1,927,745
Blooms, Billets, Slabs, Tinplate Bars	551,106	675,614	682,364	874,474	1,103,752	1,108,147
Plates	312,470	729,790	929,020	630,512	1,076,308	.....
Heavy Structural Shapes	313,733	658,516	656,797	547,186	898,537	998,624
Merchant Steel, Skelp, Hoops, Bands	577,591	1,290,970	1,527,506	1,221,606	1,910,512	2,024,192
Tubing and Pipe	654,428	1,013,071	868,550	863,670	1,111,138	1,186,740
Rods	93,406	139,149	133,722	118,302	196,720	174,478
Wire and Products of Wire	1,275,785	1,607,689	1,490,318	1,613,754	1,629,717	1,432,182
Sheets—Black, Galvanized and Tinplate	770,321	1,024,985	1,082,787	1,079,046	1,508,607	1,280,537
Finished Structural Work	403,832	530,766	589,228	518,399	599,301	652,363
Angle and Splice Bars and Joints	84,669	190,226	235,998	160,855	192,488	256,676
Spikes, Bolts, Nuts and Rivets	40,252	72,076	71,326	60,386	83,426	86,465
Axles	24,057	68,366	101,066	52,046	142,367	159,075
Sundry Iron and Steel Products	54,893	138,956	246,840	167,984	196,339	245,439
Total	6,206,932	9,857,660	10,733,995	9,476,248	12,506,619	12,374,838
Spelter	28,057	27,853	26,777	28,333	31,318	30,424
Copperas (Sulphates of Iron)	26,411	33,582	33,684	28,381	35,215	33,829
Universal Portland Cement (Bbl.)	4,535,300	5,786,000	7,001,500	7,737,500	10,114,500	11,197,000

IRON AND STEEL IN FOREIGN COUNTRIES

Africa.[1]—A new North African ore offered to eastern consumers in the year comes from the Province of Tunis. This is a hematite ore of unusually high quality, rich in iron and low in silica and alumina with phosphorus within the Bessemer limit. The railroad from mines to Bizerta,

[1] E. C. Eckel, *Iron Tr., Rev.*, Feb. 12, 1914.

and the storage plant at the latter place, have been completed only recently, and so far seven steamers have been engaged to load. The storage bins at Bizerta total 50,000 tons capacity and rapid loading is assured. Annual production is figured at 200,000 tons, most of which at present will be shipped to Europe, to which points relatively low ocean freight rates make the operation more profitable to miners than shipping to the United States. It is probable that in the near future the entire output will be taken by European blast furnaces.

STEEL PRODUCTION OF AUSTRIA-HUNGARY.
(In metric tons.)

Steel.	1912.			1913.		
	Austria.	Hungary.	Bosnia.	Austria.	Hungary.	Bosnia.
Acid converter	.....	.....	.....	843	41,738	.....
Basic converter	.....	.....	.....	232,900	.....	.....
Open-hearth	.....	.....	.....	1,500,452	749,711	33,656
Crucible	.....	.....	.....	36,653	3,089	.....
Electric	.....	.....	.....	24,902	1,935	.....
Total steel	1,953,214	793,308	33,583	1,795,750	796,473	33,656
Puddled (wrought) iron	.....	.....	.....	44,675	12,065	.....
Total	.....	.....	.....	1,840,425	808,538	33,656

PIG IRON PRODUCTION IN BELGIUM.
(In metric tons.)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Foundry iron	100,020	76,190	89,960	(a) 83,710	(a) 60,630	(a) 96,620	27,665
Forge iron	226,430	127,630	156,590	115,760	102,690	66,940	92,825
Steel pig	1,101,490	1,002,620	1,386,800	1,652,620	1,882,960	2,137,730	2,356,040
Total	1,427,940	1,206,440	1,632,350	1,852,090	2,046,280	2,301,290	2,476,530

(a) Includes special cast irons.

Brazil.[1]—The existence of large iron-ore deposits in Brazil has been known for many years, but it is only within the past few years that these deposits have given promise of becoming active factors in the ore industry of the world. Their grade and tonnage are such as to overcome disadvantages of location.

The Brazilian ores which require consideration at present are located in the state of Minas Geraes, and outcrop over extensive areas. They are hematites, high in iron and normally low in phosphorus.

As to origin, the Brazilian ores are regarded as sedimentary, occurring in original bedded deposits, with no trace of the secondary concentration which has been so effective in the Lake Superior region. As to tonnage, estimates by Merriam and Leith would justify the assumption that

[1] C. J. Stark, *Iron Tr. Rev.*, Jan. 15, 1914.

some 7,500 billion tons of ore exist, of which perhaps half will grade over 64 or 65 per cent. metallic iron, and with phosphorus below the Bessemer limit. The remainder will grade between 55 and 65 per cent. iron.

The industrial significance of these figures as to grade and reserve tonnage requires little comment. The tonnage cited is three times that credited to the Lake Superior region; the average grade is that of the ore which at one time existed on the Lakes, but which has disappeared from circulation.

Canada.[1]—The production of pig iron in Canada in 1913, including ferro-silicon, ferro-titanium, and ferro-phosphorus, amounted to 1,015,118 gross tons, against 912,878 tons in 1912, an increase of 102,240 tons, or nearly 11.2 per cent. The production in 1913 was much the largest in the history of the Dominion. For the first time the output exceeded 1,000,000 tons. Of the total 986,848 tons were made with coke and 28,270 tons with charcoal, coke and electricity, etc., against 886,506 tons made with coke and 26,372 tons made with charcoal, coke and electricity, etc., in 1912.

In the first 6 months of 1913 the output of all kinds of pig iron amounted to 545,981 tons, while in the last half of the year it amounted to 469,137 tons, a decrease of 76,844 tons, or over 14 per cent. With mineral fuel the output in the first half of the year was 532,431 tons, and in the last half it was 454,417 tons, a loss of 78,014 tons. With charcoal, electricity, etc., the output in the first half of the year was 13,550 tons, and in the second half it was 14,720 tons, a gain of 1170 tons.

The production of basic pig iron in Canada in 1913 amounted to 558,524 tons, against 489,799 tons in 1912; the production of Bessemer pig iron to 227,662 tons, against 228,742 tons in 1912; the production of foundry pig iron and ferro-silicon to 225,231 tons, against 194,208 tons in 1912; and the production of malleable Bessemer and white and mottled pig iron, direct castings, ferro-titanium, etc., to 3701 tons, against 129 tons in 1912.

In the first 6 months of 1913 the production of basic pig iron amounted to 292,625 tons, while in the second 6 months it amounted to 265,899 tons, a decrease of 26,726 tons. In Bessemer pig iron the output fell from 125,052 tons in the first half of the year to 102,610 tons in the second half, a decrease of 22,442 tons. In foundry and ferro-silicon the production in the first half of 1913 amounted to 128,293 tons, and in the second half to 96,938 tons, a loss of 31,355 tons. In malleable Bessemer and white and mottled pig iron, direct castings, ferro-titanium ferro-phosphorus, etc., there was an increase in output of 3679 tons in the last 6 months of 1913 over the first 6 months of that year.

In the following table the production of pig iron by grades in Canada

[1] Abstracted from the Statistical Bulletin of the American Iron and Steel Institute.

is given from 1900 to 1913. For 1900 foundry pig iron is included with forge and other grades of pig iron.

Years—Gross Tons.	Bessemer Pig Iron.	Basic Pig Iron.	Foundry, Ferro-silicon, etc.	Forge, etc., Including Ferro-Alloys.	Total, Gross Tons.
1905	149,203	172,102	139,528	7,170	468,003
1906	165,609	246,228	124,361	5,750	511,957
1907	154,910	341,257	78,901	6,078	581,146
1908	112,811	335,410	109,471	5,980	563,672
1909	169,545	357,965	108,608	40,972	677,090
1910	221,494	365,090	143,986	9,640	740,210
1911	186,274	413,303	190,324	34,467	824,368
1912	228,742	489,799	194,208	129	912,878
1913	227,662	558,524	225,231	3,701	1,015,118

Iron Ore.—The shipments of iron ore from the mines in Canada in 1913 amounted to 274,673 gross tons, against 192,753 tons in 1912, 187,807 tons in 1911, and 231,623 tons in 1910. (Newfoundland is not a part of Canada.) In 1913 the imported iron ore consumed by Canadian blast-furnaces amounted to 1,884,668 gross tons, against 1,802,826 tons in 1912, 1,453,900 tons in 1911, and 1,229,496 tons in 1910. Ore was imported chiefly from the United States and Newfoundland. The exports of iron ore from Canada in 1913 amounted to 112,611 gross tons, against 105,472 tons in 1912, 33,648 tons in 1911, and 102,231 tons in 1910.

Imports and Exports.—In 1913 the imports of pig iron, ferro-manganese, etc., into Canada amounted to 254,575 gross tons, against 261,152 tons in 1912. In 1913 the exports amounted to 5648 gross tons, against 6229 tons in 1912.

A considerably increased tonnage of Bathhurst, New Brunswick, ore was imported to the eastern Pennsylvania district during the year. This aggregated 72,260 tons, which is a considerable increase over the shipments of 1913. In addition, a considerable tonnage was carried over undelivered into 1914. This ore was delivered on the basis of 7 cents per unit, f. o. b. Philadelphia. Sales of Wabana, Newfoundland, ore to eastern Pennsylvania furnaces in 1913 reached about 235,000 tons and the shipments about 205,000 tons, leaving some tonnage to be carried over into the present year. This ore was sold at 7 1/4 cents per unit, f. o. b. cars Philadelphia. Early in 1914 English and German iron makers who regularly buy large quantities of this ore had closed for a heavy tonnage, but owing to the depressed state of trade, domestic users could not be induced to show any interest in making contracts.

Ore Reserves.[1]—It is still difficult to appraise the iron ore reserves of Canada, even in an approximate way. The known ore deposits of the Dominion are widely scattered over a very large area, and differ greatly in type. The intervening areas are, in many cases, little known.

[1] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914.

At present, it can be said that any attempt to estimate the ore reserves must take account of certain tonnages of sedimentary Clinton ores in Nova Scotia; of a group of fairly large magnetite deposits in New Brunswick; of a number of smaller scattered magnetite bodies in Quebec and eastern Ontario; of some developments in the Canadian portion of the Lake Superior district; and of a series of contact deposits along the Pacific coast.

Of the ores named, pretty close estimates can now be made for those in Nova Scotia, New Brunswick and British Columbia; while the Quebec and Ontario tonnages cannot be approximated very closely. Taken as a whole, it is probable that even the most conservative figuring would credit the Dominion with about 150,000,000 tons of known and partly developed iron ores; while a more enthusiastic view of the Lake ranges might increase this estimate heavily. For our present purposes, the lower figure named will be accepted.

Turning to the adjoining colony, we meet an entirely different situation, for Newfoundland possesses what is probably the largest ore tonnage in small area anywhere in the world. To add to its interest, this large reserve is almost entirely submarine.

The known and developed ores of Newfoundland are found in the south east portion of the island, and occur as a series of sedimentary beds, in rocks of origin with our own Clinton or red ores, but are of somewhat earlier geologic age. About a dozen ore beds have been located and described in various reports, but only three of these are workable. These three workable beds given an aggregate average thickness of ore of close to 30 ft. The ore is a very dense red hematite, grading 52 per cent. or over in iron, and the tonnage per square mile is very heavy.

Geologic studies give reason to suppose that the ore beds continue northwardly, and if we assume that they can be worked as far out as Cape St. Francis, the ore trough up to that point might contain some ten billion tons of ore. A certion portion of this area will be difficult to work; and in the worked portion heavy allowance must be made for ore left to support the roof. Discounting for these factors, we may fairly assume that the Wabana trough contains some 4,000,000,000 tons of recoverable ore. About half of this tonnage is controlled by the Nova Scotia Steel & Coal Co.

Chile (By C. A. Buck[1]).—The Tofo iron mines, about 30 miles north of Coquimbo, Chile, were acquired in 1913 from the Société des Hauts Fourneaux, Forges et Acieries du Chili, by the Bethlehem Chile Iron Mines Co., a subsidiary company of the Bethlehem Steel Corporation.

The Tofo ore deposit occurs near a range of mountains 4 miles

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

back from the sea coast, and 2500 ft. above the sea level. Ore is exposed from the top of the hill to a depth of 250 to 300 ft. for about a half mile in length, with no stripping whatever of rock or soil. The amount of ore in sight, without any exploration work having been done on the property, is about 25,000,000 tons; the ore showing about 68 per cent. iron of a Bessemer composition, low in sulphur and any other elements that might make a deleterious iron ore.

The French organization took out a total of about 40,000 tons of ore up to 1913, at which time this property was acquired by the Bethlehem interests. This ore was brought down to a stockpile at the coast by gravity in buckets attached to an aërial tramway, or telepherage system, of 100 tons per hour capacity, built by a German company. Through chutes in tunnels that run under the stockpile, tramway buckets are loaded and carried out to the end of a large steel cantilever bridge, which extends out over the bay where the ore can be spouted at the rate of 300 tons per hour into the hold of a ship anchored for receiving a cargo.

The present policy of the Bethlehem Chile Iron Mines Co. is to begin operations in July, 1914, by installing enough additional equipment for a continuous daily production of 1000 tons of crushed iron ore. Plans are being completed for developing the property to produce 5000 tons of ore per day beginning in 1916 and eventually increasing the output to 10,000 tons per day.

The mining operation will be the ordinary quarrying process by blasting benches 30 ft. in depth, breaking up the ore so that it can be loaded by 6-cu. yd. shovels into 50-ton side-dump cars. These cars will be handled in trains over a standard-gage spiral railroad down the benches to a crushing plant. The ore will be crushed to 4 in. and passed by gravity to loading bins, from which 70-ton hopper cars can be loaded. From this point ore trains, controlled by electric locomotives, will run 12 miles by gravity down a 3 per cent. grade, winding down the side of the hills to the bay at Cruz Grande, where modern ore docks of 30,000 tons capacity will be erected. Current generated by the loaded trains going down the hill will supply power for hauling the empty trains up the hill. The ore will be shipped in 15,000-ton cargoes through the Panama Canal to the Bethlehem Steel Co. A power plant will supply current for the various mining operations. Well-equipped machine, boiler and blacksmith shops and foundry will be installed and two villages will be built for the comfort and convenience of the employees.

Ore Reserves.[1]—It is highly probable that in the future large deposits of residual brown ores, similar to those of the north coast of Cuba, will be located in South America, but at present the known ore deposits, outside

[1] E. C. Eckel, *Iron Tr. Rev.*, Jan. 15, 1914.

those of Brazil, are of two different types. In Chile, and all along the west coast of South America, there are a number of deposits of high-grade ores, often mixed magnetite and hematite, and apparently similar in origin and character to the contact deposits of Mexico and British Columbia. The known deposits of Venezuela, on the other hand, appear to be more closely allied to the magnetite deposits of the Adirondacks and other portions of the eastern United States.

Taking the Venezuelan and Chilean deposits together, it seems probable that 200,000,000 tons would be a fair estimate of the ore which has been prospected and partly developed to date. There are, of course, large possibilities in excess of this tonnage, but on the other hand, some of the deposits are of a type whose tonnage is particularly easy to overestimate. A maximum estimate, to cover probable development, might run as high as 500,000,000 tons for the ores of the northern and western portions of South America.

China (By T. T. Read).—The principal production of iron and steel in China is by the Han-Yeh-Ping Iron & Coal Co., with coal mines and coke ovens at Pinghsiang, iron mines at Tayeh, and blast and steel furnaces at Hanyang, near Hankow. The ancient native industry in Shansi, by which rather low-grade ores are reduced in crucibles, the resulting blooms hammered into wrought iron, and the smaller pieces of metal melted with powdered coal and cast into a great variety of objects, is slowly declining, as the continual increase of imports of scrap steel, old horseshoes, wire shorts, etc., takes away the market for the native wrought iron, which is not of uniform quality, so that the native output, which once reached 50,000 tons per year, is now gradually falling off. The Han-Yeh-Ping Co. had a bad year in 1912, all the furnace plant having been shut down on account of the damage done during the revolution and only 2 months' operation was secured during the year. The iron mines at Tayeh were kept in operation and 192,980 tons were mined, much of this going to Japan to fill the contracts with the firms in that country. During 1912 two blast furnaces having a capacity of 125 tons per day each were put in working order and a third 250 ton furnace was repaired early in 1913. It is proposed to build another 300 ton blast furnace. The following data as to the character of the output of this company given by J. P. Jameson in a consular report will be of interest.

Inquiry has been made regarding the price at which pig iron can be furnished by the Hanyang Iron & Steel Works. The company states that for local sales of foundry pig iron in Hankow it is receiving 33.50 Hankow taels ($22.52 U. S. gold at present quarterly exchange rate of $0.669) per ton ex works. The analyses of the Hanyang foundry pig and open-hearth steel are:

	Silicon.	Manganese.	Phosphorus.	Sulphur.	Carbon.
Foundry:	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
No. 1	2.5–3.0	0.5–1.0	0.1–0.0	0.02–0.03	3.5–3.8
No. 2	2.0–2.5	0.5–1.0	0.1–0.0	0.02–0.04	3.0–5.4
No. 3	1.5–2.0	0.5–0.9	0.1–0.2	0.04–0.05	3.0–3.5
No. 4	1.0–1.5	0.5	0.1–0.2	0.05–0.08	2.5–3.0
Siemens-Martin	0.8–1.5	1.0–1.5	0.1–0.2	0.01–0.05	3.0–3.5

The output of the Han-Yeh-Ping Iron & Coal Co., during 1911 and 1912, was as follows:

	1911.	1912.		1911.	1912.
	Tons.	Tons.		Tons.	Tons.
Pig iron	93,336	*a*7,889	Iron ores	359,467	*b*192,980
Steel materials	1,250	*a*2,521	Coal	274,002	*b*232,373
Steel rails	24,215	*a*1,120	Coke	170,539	*c*29,109
Total manufactures.	118,801	*a*11,530			

a 2 months only. *b* 12 months. *c* 1 month only.

During the past year the capital of the Pen Hsi Hu Colliery & Mining Co. has been increased to $2,500,000. Of this $1,500,000 has been set aside for the exploitation of the iron deposits not far from Pen Hsi Hu, which is a short distance southeast of Mikden on the line connecting that place with Antung. The ore is magnetite, some of it as high as 70 per cent. iron and an estimated credited to a Japanese geologist gives the amount of probable ore as 80,000,000 tons. A 100-ton blast furnace is expected to be in operation by the end of this year and present plans call for the construction of three such furnaces. German machinery is being used. At present it is generally understood that the Bethlehem Steel Co. is engaged in the search for valuable ore deposits in China.

It is stated in the *Seoul Press* that the export of iron ore from Chosen (or Korea) through the port of Chinnampo is very active. Shipments during 1913 up to December 15 totaled 135,263 tons, an increase of more than 3000 tons over the previous year. Of the total amount, 44,000 tons came from Eunyul, 46,500 tons from Chailyong, 34,183 tons from Anak, and 10,500 tons from Sinchon.

Cuba.—The iron ore deposits of the Mayari division of the Spanish American Iron Co. occur on an irregular plateau about 15 miles long and 4 miles wide, and at an elevation of 1700 to 2200 ft., on the north coast of Cuba, almost directly north of Santiago de Cuba. These deposits, together with those owned by the same company at Daiquiri, on the south coast, have been described in some detail by James E. Little, in the *Transactions of the American Institute of Mining Engineers*, Vol. XLII, p. 152, to which reference should be made for further details.

Shipments of Cuban ore[1] to the United States in 1913, again estab-

[1] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914.

lished a new high record and were 1,635,622 tons, compared with 1,392,-211 tons in 1912, or an increase of about 200,000 tons. In 1911, they amounted to 1,162,786 tons, and in 1910, 1,429,348 tons. The three leading Cuban shippers imported about the following quantities: Spanish-American Iron Co., 1,080,000 tons; Juragua Iron Co., 375,000 tons; Bethelhem Steel Co., 370,000 tons; Ponupo Manganese Co., 145,000 tons. This high record of output was established by the operations during the first 8 to 10 months of the year, as following that period, in harmony with the decline of the eastern iron and steel industry, shipments fell away considerably. Having shipped out its full obligations of ore and with buyers indifferent toward placing new contracts, the Ponupo Manganese Co. closed its mines at Nima Nima on Dec. 1, and these are idle at the present time. When they will resume, will depend upon the state of the iron trade and upon the revival of demand for ore among eastern furnaces. The Spanish-American Iron Co. shipped heavily throughout the year. Because of the active operations through most of the year, of the furnaces of the Pennsylvania Steel Co. and of the Maryland Steel Co., its affiliated interests, which consume this ore, this company kept up its movement to the very close. This continued heavy shipping was due largely to the presence of annual transportation arrangements which did not expire until the end of the year. At the opening of 1914, however, this producer cut its operations to less than 50 per cent. in both the Diaquiri or south coast and the Mayari or north coast mines, and was shipping about 40,000 tons a month, compared with an average of about 90,000 tons monthly in 1913.

Shipments from the south coast, Diaquiri deposits, in 1914, were about 1,110,000 tons, compared with 946,035 tons in 1912, 774,994 tons in 1910, 1,126,834 tons in 1910, and 968,342 tons in 1909. The ore brought into this country last year from the Mayari or north coast deposits, where the ore is transported in the form of nodules, was 491,713 tons. This compares with 446,176 tons in 1912, 387,792 tons in 1911, 302,505 tons in 1910, and 516 tons in 1909, where these workings were opened.

CUBAN ORE SHIPMENTS IN RECENT YEARS.

	Total.	South coast.	North coast.
1913	(a) 1,600,000	(a) 1,110,000	491,713
1912	1,392,211	946,035	446,176
1911	1,163,786	774,994	387,792
1910	1,429,348	1,126,843	302,505
1909	968,858	968,342	516

(a) Approximate.

Ore Reserves.—The high-grade hematites which formed the original source of Cuban ore shipments are derived from a series of deposits on the south coast, near Santiago. These deposits are now estimated to

contain, according to various engineers, a total of from five to eight million tons of ore. Similar ores occur elsewhere in Cuba, as well as in Porto Rico; but no large additional tonnage can be credited to them.

With regard to the brown ore deposits which fringe the eastern portion of the north coast of Cuba, the situation as regards reserve tonnages is very different. These brown ores cover extensive areas, and the deposits are fairly regular in thickness, character, etc. Current estimates from various sources agree closely in placing the total at about three thousand million tons. This corresponds to approximately two thousand million tons of dried commercial ore, but in the present discussion the crude ore figures will be used and the necessary correction can be made by using also the crude ore average grade, say 35 per cent. natural.

France.—Imports of iron ore into France for the year 1913 were 1,417,063 metric tons, a decrease of 37,127 tons from 1912. Exports were 9,745,863 tons, an increase of 1,422,151 tons.

PIG-IRON PRODUCTION IN FRANCE.
(In metric tons.)

	1906.	1907.	1908.	1909.	1910.	1911 (a).	1912(a).	1913.
Foundry	591,275	651,700	695,527	749,247	760,622	836,454	825,682	.....
Forge	741,571	673,885	543,067	538,053	556,767	586,496	568,164	.....
Bessemer	149,971	122,046	118,121	118,002	104,966	104,265	117,221	.....
Basic	1,784,726	1,988,343	1,949,107	2,172,718	2,549,908	2,777,261	3,304,518	.....
Special irons	51,489	152,975	85,328	54,085	60,196	122,113	56,407	.....
Total	3,319,032	3,588,949	3,391,150	3,632,105	4,032,459	4,426,469	4,871,992	5,311,316

(a) As reported by the Comité des Forges.

IRON AND STEEL PRODUCTION IN FRANCE.
(In metric tons.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Wrought iron	747,900	687,249	563,745	519,200	501,100	462,681	(e)450,000	.....
Steel ingots	2,436,322	2,766,773	2,727,617	3,034,571	3,506,497	3,680,613	4,078,352	4,419,241
Finished steel	1,454,456	2,261,217	1,894,022	2,043,022	2,684,000	2,638,484	3,028,799	2,993,050

(e) Estimated.

Germany.—The following table gives statistics of Germany's exports of iron and steel for the entire years 1912 and 1913, in metric tons.

	1912.	1913.
Pig iron	1,058,843	856,431
Scrap	160,732	196,221
Semi-finished steel	695,263	700,779
Structural steel	1,343,837	1,619,485
Plates	423,902	610,179
Wire	485,195	527,688
Tubing	169,764	209,457
Steel rails	523,218	500,835
Steel railroad ties	191,590	134,293

The total exports of iron and steel for the year amounted to 6,497,000 tons, as compared with 6,042,000 tons in 1912, an increase of 455,000 tons. Imports were 618,000 in 1913, as against 674,000 tons in 1912, a decrease of 56,000 tons.

PRODUCTION OF PIG IRON IN GERMANY
(In metric tons.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Foundry iron.	2,108,684	2,259,416	2,254,644	2,491,919	2,968,810	2,881,059	3,355,177	3,640,074
Forge iron...	854,536	786,113	635,228	652,306	644,992	689,881	525,423	489,783
Steel pig.....	943,573	1,034,650	934,940	1,099,779	1,327,196	1,547,480	2,201,489	2,599,887
Bessemer pig.	482,740	471,355	361,472	412,118	471,366	377,051	388,855	368,840
Thomas pig..	8,088,534	8,494,226	7,627,227	8,261,538	9,338,961	9,785,056	11,397,965	12,193,336
Total.....	12,478,067	13,045,760	11,813,511	12,917,653	14,793,325	15,280,527	17,868,909	19,291,920

PRODUCTION OF STEEL IN GERMANY.
(In metric tons.)

	1910.		1911.		1912 (a).		1913.	
	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.
Converter ingots...	171,108	8,030,571	187,359	8,640,164	187,179	9,794,300	155,138	10,629,697
Open-hearth ingots	252,148	5,125,421	383,895	5,668,501	295,256	6,871,896	380,155	7,592,901
Special steels.....	119,390	.....	139,414	.....	153,367	.....	200,928	.....
Total (b).....	542,646	13,155,992	710,668	14,308,665	635,802	16,666,196	736,221	18,222,598

(a) As reported by the German Iron and Steel Union. (b) Includes direct castings.

Great Britain.—The exports of British iron and steel for 1913 show an increase over those for 1912, but it is not large. The total sent abroad for the year, excluding iron ore and including scrap, was 5,050,919 gross tons, as against 4,933,112 tons for 1912, an increase of 117,807 tons. In value the increase is £5,733,469, the total exports for 1913 being valued at £54,729,302 as compared with £48,995,833 for 1912. The decrease in pig-iron exports continues, the total, including ferro-alloys, being 1,124,815 gross tons for 1913, as compared with 1,262,383 tons for 1912. Of galvanized sheets the exports were 762,244 gross tons for 1913, as against 658,650 tons for 1912, an increase of 103,594 tons.

Iron and steel imports for 1913, excluding iron ore and including scrap, show an increase of 282,757 tons, totaling 2,343,709 tons, as compared with 2,059,952 tons for 1912. The values for the 2 years are £15,618,031 and £13,153,247, respectively.

In manufactured iron and steel the exports were considerably larger than in any previous year, particularly as regards sheets, which were about 38 per cent. of the total exports. The increase of 100,000 tons in galvanized sheets was noteworthy. Exports of rails for 1913 were over 500,000 gross tons, a figure that has been exceeded only three times in

the past 10 years. The imports of iron ore were 7,442,000 tons, against 6,600,000 tons in 1912, a figure exceeded in only two or three previous years. In manufactured iron and steel the total imports for 1913 were 2,000,000 gross tons as against 1,779,000 tons in 1912. The remarkable fact about the import figures is that semi-finished and finished material, excluding pig iron, now amount to over 50 per cent. of the semi-finished and finished exports.

Imports of iron ore for the year 1912 amounted to 6,602,483 tons, and for the year 1913 increased to 7,442,329 tons.

UNITED KINGDOM, PIG IRON AND WROUGHT IRON.
(In tons of 2240 lb.)

	1911.	1912.	1913.
Pig iron	9,718,638	8,889,000	10,479,171
Wrought or puddled iron	1,191,499	1,326,917	.....

PRODUCTION OF STEEL IN THE UNITED KINGDOM.
(In tons of 2240 lb.)

	1903.	1904.	1905.	1906.	1907	1908.	1909.	1910.
Open-hearth	3,124,083	3,245,346	3,879,748	4,554,936	4,663,489	3,817,103	4,148,408	4,595,366
Bessemer	910,018	1,781,533	2,009,712	1,907,338	1,859,259	1,478,539	1,733,220	1,779,115
Total	4,034,101	5,026,879	5,889,460	6,462,274	6,522,748	5,295,642	5,881,628	6,374,481

ACID AND BASIC STEEL IN THE UNITED KINGDOM.
(In tons of 2240 lb.)

	1911.			1912			1913.		
	Acid.	Basic.	Total.	Acid.	Basic.	Total.	Acid.	Basic.	Total.
Open-hearth	3,121,218	1,899,254	5,000,472	.....	.....	5,273,657	3,811,382	2,251,793	1,600,701
Converter	887,767	573,373	1,461,140	.....	.....	1,522,487	1,048,772	551,929	6,063,175
Total	4,018,985	2,442,627	6,461,612	.....	.....	6,796,144	4,860,154	2,803,722	7,663,876

IRON AND STEEL EXPORTS, UNITED KINGDOM.
(In tons of 2240 lb.)

	1907.	1908.	1909.	1910.	1911.	1912(a).	1913(a).
Pig iron	1,947,925	1,295,767	1,136,369	1,205,863	1,204,319	1,124,815	1,097,009
Wrought iron	211,771	172,072	170,189	141,747	138,089	142,461	137,335
Sheets	469,329	390,281	494,826	597,117	617,557	762,244	762,744
Plates	300,590	207,278	167,797	250,867	267,691	282,898	273,051
Rails	433,638	435,739	571,524	485,693	370,543	412,127	509,105
Steel shapes, etc.	338,716	275,022	305,530	369,020	347,828	361,992	368,498
Tin plates	405,329	403,007	439,804	483,020	484,355	480,910	495,246
All other kinds	1,059,068	921,810	932,024	1,206,578	1,088,727	1,211,102	1,295,453

(a) From official Trade and Navigation Accounts.

Russia.—Because the Russian blast furnace companies which are in the association known as the Prodamet cannot produce sufficient pig iron to satisfy the growing needs of the iron and steel consuming industries and because importation is prohibited, the question of supplying the need became so acute early this year that a special conference took up the question. It was summoned by the Russian Minister of Commerce and included the pig-iron producers, the railroad representatives and various industrial experts. It was shown that the Russian output of pig iron for 1914 would not exceed 4,000,000 tons, about 450,000 tons greater than in 1913, while 5,000,000 tons would be needed. It was decided to allow the importation, duty free, for one year of a quantity of pig iron, and axles to be fixed by an expert appointed by the government.

PRODUCTION OF IRON AND STEEL IN RUSSIA.
(In metric tons.)

	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
Iron ore	4,218,600	5,272,300	4,060,000	4,580,000	4,400,000	4,450,000	4,750,000	4,595,000	5,101,000
Pig iron	2,486,610	2,978,325	2,125,000	2,350,000	2,768,220	2,748,000	2,871,382	2,740,000	2,865,000
Steel ingots	2,410,938	2,811,948	1,650,000	1,763,000	2,076,000	2,241,000	2,477,000	2,350,000	2,519,000

Spain.[1]—Deliveries of Spanish ore to the eastern market the past year showed some increase over 1912 and totaled 113,000 tons. The official statistics of 1912 show them, then, to have been 92,061 tons. This ore was sold upon the basis of about 7 cents per unit, f. o. b. Philadelphia, for Bessemer material. The shipments of Spanish ore of the past year further have emphasized the decreased importance of this ore as a competitive material in the eastern Pennsylvania market. This falling off of trans-Atlantic ore shipments has come about through the greater difficulty of chartering vessel tonnage for the long haul at rates which would permit this material to be offered at competitive prices at eastern seaboard and the further fact that better prices have been obtainable from English and other European consumers much nearer the mines. The high point in Spanish ore shipments to this country was attained in 1910, when 440,000 tons were imported.

Sweden.—Swedish iron-ore exports for the year 1913 were 6,459,950 tons, an increase of 919,297 tons, or 16.7 per cent. over the preceding year.

There were in operation in 1913 a total of 104 blast furnaces, 210 puddling furnaces, 17 bessemer converters and 62 open-hearth furnaces.

In 1913, Swedish mines[1] shipped approximately 375,000 tons of magnetite to eastern blast furnaces in the United States. The total compares with 333,863 tons brought in in 1912. As usual, the ore came from the Kirunavaare deposits in Swedish Lapland. All the

[1] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914.

Swedish ore imported in 1913 went to the Bethlehem Steel Co. and the Reading Iron Co. under long-term arrangements which have been in force for several years. None of this material was sold in the open market, so that the price was fixed upon it in the year as a result of new transactions. Approximately 300,000 tons were received by the Bethlehem Steel Co. In 1914, by the terms of this contract, 350,000 tons of ore are to be brought in, and this will remain the fixed maximum tonnage until the expiration of the contract.

SWEDISH PRODUCTION AND EXPORTS.
(In metric tons.)

	1911.			1912.			1913.		
	Pig Iron.	Wrought Iron.	Steel.	Pig Iron.	Wrought Iron.	Steel.	Pig. Iron.	Wrought Iron.	Steel.
Production	633,800	146,700	(c)456,500	701,900	148,100	(a)508,300	735,000	153,400	(b)582,800
Exports....	158,400	90,600	169,300	204,800	85,300	190,300	207,500	295	,100

(a) Includes 107,200 tons bessemer and 401,100 open-hearth. (b) Includes 115,700 tons bessemer and 467,100 tons open-hearth. (c) Includes 93,800 tons bessemer and 362,700 tons open-hearth steel.

Venezuela.[1]—South America deposits has continued to attract considerable attention, as eventual resources for this country, especially after the Panama canal is completed. The only country of the continent to ship ore to the United States last year, however, was Venezuela. Shipments of Venezuelan ore from the workings at Imataca increased considerably and totaled about 59,000 tons. In 1913, the imports were about 10,000 tons. Practically all the past year's tonnage was received by the Alan Wood Iron and Steel Co. for its furnace plant at Swedeland, Pa., under the contract closed early in the year with the Canadian-Venezuelan Ore Co., Ltd., which operates the property, and providing for 100,000 tons annually for a period of 5 years. The shipments under this contract fell off considerably during the last quarter and the full annual quota was not realized.

PIG-IRON PRODUCTION OF THE WORLD.
(In metric tons.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1904.....	1,369,500	1,307,399	274,777	2,999,787	10,103,941	27,600	2,978,325
1905.....	1,372,300	1,310,290	475,491	3,077,000	10,987,623	31,300	2,125,000
1906.....	1,403,500	1,431,160	550,618	3,319,032	12,478,067	30,450	2,350,000
1907.....	1,405,000	1,427,940	590,444	3,588,949	13,045,760	32,000	2,768,220
1908.....	1,650,000	1,206,440	572,123	3,391,150	11,813,511	112,924	2,748,000
1909.....	1,958,786	1,632,350	687,923	3,632,105	12,917,653	207,800	2,871,332
1910.....	2,010,000	1,852,090	752,090	4,032,459	14,793,325	215,000	3,042,046
1911.....	2,095,000	2,046,280	837,558	4,426,469	15,280,527	235,000	3,588,449
1912.....	2,312,689	2,301,290	927,484	4,871,992	17,852,571	379,987	3,726,000
1913.....	(a)1,757,864	2,484,690	1,023,973	5,311,316	.....	.....	3,801,273

[1] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914. (a) Austria alone.

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1904.....	386,000	528,525	8,699,661	16,760,986	633,000	46,069,501
1905.....	383,100	531,200	9,746,221	23,340,258	655,000	54,054,783
1906.....	357,500	552,250	10,311,778	25,706,882	650,000	59,074,861
1907.....	385,000	603,100	10,062,638	26,193,863	556,900	60,680,014
1908.....	403,500	563,300	9,438,477	16,190,994	550,000	48,640,479
1909.....	389,000	443,000	9,818,916	26,108,199	550,000	61,217,064
1910.....	367,000	604,300	10,380,723	27,636,637	525,000	65,908,674
1911.....	353,500	633,800	9,874,620	24,027,940	535,000	63,210,694
1912.....	366,136	701,900	9,037,150	30,202,568	.....	.....
1913.....	.....	.....	10,653,824	.....	.....	.....

STEEL PRODUCTION OF THE WORLD.
(In metric tons.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1903.....	1,146,000	981,740	181,514	1,854,620	8,801,515	116,000	2,410,938
1904.....	1,195,000	1,069,880	151,165	2,080,554	8,930,291	113,800	2,311,948
1905.....	1,188,000	1,023,500	403,449	2,210,284	10,066,553	117,300	1,650,000
1906.....	1,195,000	1,185,660	515,200	2,371,377	11,135,085	109,000	1,763,000
1907.....	1,195,500	1,183,500	516,300	2,677,805	12,063,632	115,000	2,076,000
1908.....	2,025,132	1,065,500	598,183	2,727,717	10,480,349	537,000	2,341,000
1909.....	1,969,538	1,370,000	766,795	3,034,571	12,049,834	661,600	2,471,000
1910.....	2,188,371	1,449,500	835,478	3,506,497	13,698,638	635,000	2,350,000
1911.....	2,363,008	1,537,000	880,278	3,680,613	15,019,333	646,500	2,519,000
1912.....	2,785,105	1,954,490	.....	4,078,352	17,868,909	.....	.....
1913.....	2,682,619	.....	.....	4,419,241	19,291,920	.....	.....

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1903.....	199,642	317,107	5,114,647	14,756,691	418,000	36,296,414
1904.....	198,759	333,522	5,107,309	13,746,051	415,000	36,148,079
1905.....	227,864	340,000	5,983,691	20,354,291	426,000	43,900,648
1906.....	251,800	351,900	6,565,670	23,772,506	420,000	49,635,998
1907.....	247,100	443,000	6,627,112	23,733,391	405,000	51,273,340
1908.....	239,500	427,100	5,380,372	14,247,619	300,000	44,359,522
1909.....	227,000	310,600	5,975,734	24,338,302	325,000	53,499,974
1910.....	220,000	468,600	6,476,791	26,512,437	315,000	58,656,312
1911.....	228,230	456,500	6,565,321	24,054,918	325,000	58,275,701
1912.....	.....	508,300	6,689,118	31,751,324	.....	.....
1913.....	.....	.....	7,543,187	31,822,555	.....	.....

THE METALLURGY OF IRON AND STEEL IN 1913

BY BRADLEY STOUGHTON

Alloy Steels.—Manganese steel, which is very extensively used for parts of crushing machinery and other apparatus which is subjected to great wear, is now commercially forged both hot and cold. It can also be made either non-magnetic or magnetic, and has the great peculiarity of indicating changes in structure that do not seem to be related to critical points in its heating and cooling curves. Mayari cast iron and steel are natural alloys of iron, nickel and chromium which can be made from some of the ores of Cuba and some of the ores of Greece without the addition

of any alloying materials. They have increased strength, hardness and durability over corresponding irons and steel without the nickel and chromium, and are coming into extensive use in engineering. Cobalt is one of the latest additions to steel and is said to give greatly increased durability, especially in high-speed steels.

Steel containing from 0.1 to 0.5 per cent. of copper has been experimented with by many investigators in recent years for material giving extra resistance to crushing and durability against wear, as for example, in railroad rails. Steel containing about 0.02 per cent. of copper has also been tested for its corrosion-resisting properties, with results which are at least interesting. Clevenger has shown that copper steel forges well up to a content of 4 per cent. copper, and good welds were made with as high as 0.8 per cent. copper. The effect of the copper is to lower the A_1 critical point, to increase the elastic limit and hardness of the steel. A scientific study has also been made of the ternary alloys of iron, manganese and copper.

Gases in Steel.—The injurious effect of nitrogen on steel, which has been debated somewhat hotly for the past two years, received further confirmation in a lengthy research published in 1913. A much-needed method for the rapid determination of nitrogen in steel was also described; it depends upon the use of dimethylglyoxime. Attempts have been made to introduce oxygen into steel upon the supposition that it will benefit strength and ductility, and it has been shown that not more than 0.075 per cent. oxygen may be retained in the steel bath. Upon the much-discussed question of the rapid determination of oxygen in steel, several investigations have been published. We are nearer a solution of that important problem without yet having reached it. In this connection a sharp distinction must be drawn between the oxygen united with, or held by, the iron, as distinguished from the oxygen united with manganese, silicon, etc., mechanically occluded by the steel. The whole question of the effect of oxygen on both cast iron and steel is being considered with a degree of attention that indicates very important developments in the near future. Charpy and Bonnerot announce that when hydrogen is made to diffuse through iron at a red heat, none of the gas is absorbed by the metal, and that sulphur, phosphorus and carbon are removed as hydrides, the strongest effect being noted in the case of sulphur.

Liquid Air in Relation to the Steel Industry.—The cheap production of oxygen through the manufacture of liquid air and the constantly decreasing cost of this manufacture through lowering the cost of producing power, one important means of which is the power produced by iron blast-furnace by-products, augments each year the amount of oxygen used for enriching blast, not only for the blast-furnace, but also for the Bessemer

converter. Attention has been called[1] to the use of liquid oxygen for enriching the blast of a basic bessemer converter raised the temperature from the normal of, say, less than 1700° C., to about 2000° C.

Properties of Cast Iron.—A very important investigation by J. E. Johnson, Jr., was published in 1913 upon the Effect of Carbon on the Quality of Cast Iron, and the very important influence of the eutectic ratio upon the properties of this metal. Subsequently the same investigator published a research upon the strengthening effect of oxygen upon cast iron.

Allotropic Modifications.—The work of H. C. H. Carpenter and others has thrown considerable doubt upon the existence of the so-called hard Beta allotropic modification. The latter investigator has also doubted the existence of the A_2 critical point, but this doubt has been shown by Howe and Burgess to be wholly untenable. Howe has devised a new and improved method for determining the A_2 critical point, and Stead has devised a new method for locating A_1.

Sound Steel Ingots.—In this very important particular notable advances have been made during the year 1913.

It is comparatively easy to tell by the usual tests whether the structure and composition of steel equals a given standard or quality, but certain dangerous defects, which may be inherent in the metal, will often escape the ordinary study that is given, and may be difficult to discover even by such extraordinary investigations as sulphur-prints, microscopic examinations, hardness tests, shock tests, etc., unless these are carried on at such an extensive scale as to destroy the steel for service. Defects ot this character are generally classified under the head of unsoundness, and the chief ones may be described as follows:

1. Presence of blow-holes
2. Presence of occluded oxides
3. Presence of unwelded shrinkage cavities
4. Excessive segregation

The most effective means of preventing these elements of unsoundness is by the exercise of great care and watchfulness during the manufacture of the steel and during the manufacture of the iron from which the steel is made. It now seems to be removed practically beyond controversy that certain unfavorable conditions during the smelting of iron ores in blast-furnaces will produce a grade of pig iron which, during the ordinary process of manufacture will be converted into an unsatisfactory grade of steel. It is not our purpose to discuss this matter at length in this paper, but the literature on cast iron during the years 1913 and 1914

[1] *Eng. Min. Jour.*, Vol. XCV, p. 1054.

will be ample proof of the accuracy of this statement, and fortunately, careful and expert inspection of the manufacturing process, and suitable testing of the product, is sufficient to prevent steel of this undesirable quality going into service. Expert care and inspection during the manufacture and rolling of steel is also the best safeguard for preventing steel which is unsound from any of the other causes mentioned above going into the service of the consumer. One of the greatest advances ever made in the manufacture of steel is the new system of inspection inaugurated under that great engineer and metallurgist, Robert W. Hunt, as described by him at recent gatherings of scientists.[1]

An English and an American investigator have used the compression process for elimination of the pipe in a way which aims to eliminate interference with the manufacturing process and interest on the investment, by taking the steel ingot before it has completely solidified and reducing its section in an ordinary pair of blooming rolls, then returning it to the heating furnace until completely solidified and completing the rolling operation in the usual way. Other recent investigators have aimed to accomplish the same reduction in the cost of treating the steel over the early compression process, but none of these latter inventions secures the elimination of the shrinkage cavity, but only its reduction to a smaller size or a greater concentration at the top of the ingot, with a consequent smaller proportion of cropped-off metal being required.

Sir Robert Hadfield burns charcoal on top of the steel ingots in a special mold with a sand top, so as to delay the cooling of this portion of the metal, and consequently draw the shrinkage cavity to that point.

Emil Gathmann, by a very ingenious method of casting ingots with the smaller end down, and then stripping them without excessive inconvenience, as well as by distributing the metal in his ingot-molds, also produces a more rapid cooling of the lower parts of the ingot than of the top, and thereby concentrates the cavity in the upper portion.

The Goldschmidt process involves heating metal in the top of the ingot by the well-known Thermit reaction, or else by creating a separate reaction in the ingot by means of a can of thermit, by means of which it is claimed that blow-holes, pipes and segregation are all reduced.

Each of these cavity reducing processes has been tried on a commercial scale long enough to prove its advantage under a given state of conditions.

Also a new compression process which has been used chiefly on

[1] Hunt: Recent Developments in the Inspection of Steel Rails, *Bull.* No. 72, *A. I. M. E.*, December, 1912, pp. 1487–1495.
Hunt: Comparative Notes on Steel Rail Rolling, *Bull.* No. 77, *A. I. M. E.*, May, 1913, pp. 879–883.

smaller ingots with a split mold, is in commercial use; and a process has even been developed for treating steel *in vacuo*, in order to get rid of the dissolved gases and occluded solid particles.

Pulverized Coal as a Metallurgical Fuel.—Besides its use in cement kilns, annealing ovens, heating furnaces, etc., pulverized coal has now been used successfully for more than a year for heating retorts and open-hearth furnaces, and this type of fuel bids fair to greatly increase in importance in the near future, due to its inherent advantage in the possibility of reaching a very high temperature, as well as its relative economy at the present time as compared to oil, tar, etc.

Ore Deposits.—The acquisition of iron ore holdings in Chile by a large American company has again drawn attention to the deposits of iron ore in Brazil and Venezuela, both of which are known to be very large in extent. They have also reported large deposits of iron ore in Colombia. The manganese ores of India are coming to the front. Development work in Siberia, where large deposits are known to exist, is more active; important deposits of chrome iron ore are reported from Northern Caucasus. In the United States, the Texas iron ores are being more actively developed by the building of large smelting works in this State, and an important innovation is the treatment of the titaniferous ores on an industrial scale. That these ores can be treated has long been known, but attempts at industrial smelting have been sporadic. Nevertheless, numerous deposits of this class of ore are known to be available in this country, in Sweden and elsewhere.

Ore Briquetting.—It is well recognized that the more uniform the size of material treated in the blast-furnace, the better are the smelting results obtained as to efficiency and economy. The two ways of securing uniform size are by crushing the larger particles and agglomerating the smaller ones. Agglomerating processes have, therefore, increased in importance during the past few years. The only new process of importance is the Scoria process, whereby the fine ore is mixed with lime and agglomerated slag, heated in rotating steam drums, and then made into bricks and heated in kilns. The slag is said to keep the solid body porous, and when it reaches the melting zone it changes from being a hydraulic binder to being a fused binder.

It has been pointed out that the use of agglomerated material made by the sintering process has the further advantage that the resulting "sinter" is not so easily reducible as some of the native American ores and, therefore, does oxidize the coke in the upper regions of the furnace whereby it obtained a greater proportion of carbon monoxide in the escaping gases, with consequent increased efficiency.

Blast-Furnace Operations.—An important improvement in blast-fur-

nace gas cleaning is removing the impurities without introducing moisture into the gas by the use of the bag process. It has been suggested that blast-furnace dust might be used as an addition to cement, but experiments made therewith indicate that it is weakening in its effect. One plant is installing the Cottrell process for cleaning the gas.

There is a steady increase in the use of dry blast, and also in the use of blast-furnace blast, as well as bessemer blast, enriched in oxygen. There seems to be no doubt of the industrial importance of this practice, which will constantly increase as the price of oxygen is reduced. In the matter of thin lining there seems to be a slow but certain return to a line midway in thickness between the extreme 9 in. used in some cases and the 24 to 36 in. thickness of earlier days. Twelve to fourteen inches seems to be more generally adopted at the present time.

There is also a constant increase in blast-furnace gas used in gas engines, and especially in mixtures of blast-furnace gas with coke oven gas. A discussion of more than ordinary interest took place in 1913 between the advocates of gas engines and steam engines as to relative efficiency and economy.

Improvements in Foundry Practice.—A new method of dephosphorizing iron in the foundry, which is similar in principle to the Bell-Krupp method, has been patented in Sweden. An American inventor has also patented a process which is said to reduce phosphorus. It consists in blowing air through a bath of molten iron in such a way as to produce a gentle ebullition with the purpose of causing the impurity slowly to rise to the top and at the same time avoiding the bessemerization of impurities. The process is differentiated from the ordinary bessemer process in that it decreases instead of increases the heat.

Foundry Cupolas.—Extended investigations have been made upon iron cupola melting operations by German, Swedish, French, and American experimenters, which have resulted in showing that the greater part of the heat is lost in the gases which pass out of the top of the chimney, and that great economies may be effected by increasing the height of the cupola. A second innovation is melting turnings and borings by blowing them in with the blast through the tuyères. A third suggested change is to incline the tuyères at an angle of 40° to the horizontal; and a fourth, consists in a patented Swedish process for dephosphorizing the iron by oxidation with iron ore at a low temperature.

Electric Furnaces.—There has been a marked increase in the relative importance of electric steel furnaces for casting work, on account of the superior quality of the electric steel for this purpose, as well as the commerical difficulties in the way of producing forging steel super-refined in the electric furnace in competition with ordinary bessemer and open-

hearth steel. There are now 19 electric furnaces in operation in America, and nearly 150 total in all countries. The commercial manufacture of ferro-alloys in the electric furnace continues to increase, but the smelting of iron ore to produce pig iron has not yet justified the early expectations of its advocates. The question of refractories in electric furnace work is a difficult one, and a new refractory which has attracted some attention is said to be a nitride of boron. W. R. Walker has patented his process for recarburizing the steel in the ladle before it goes to the electric furnace for super-refining, instead of afterward.

Open-hearth Furnaces.—The use of open-hearth furnaces with replaceable up-takes and flues is increasing in Europe. It has been pointed out, however, that this is not a modern invention, but was in use several years ago in this country. A very elaborate heat-efficiency test of the open-hearth furnace made on two 60-ton furnaces indicates that only 10 per cent. of the heat supplied goes to the melting and less than 19 per cent. performs useful work. This confirms the belief that the open-hearth furnace is not an efficient heat utilizer. A few years ago it was generally believed that the tilting open-hearth furnaces would no longer be an important factor outside of special processes. During 1913 there has, however, been a big revival of interest in this type of steel producer.

Other Steel-making Processes.—A very remarkable record has been made by a crucible furnace, which ran 3 years, 9 months and 11 days continuously without requiring to be shut down for repairs. It is believed that this establishes an extraordinary record for this kind of furnace. A combination open-hearth, side-blow converter and electric furnace has been installed and recently put into operation at a steel plant in Maryland. The apparatus has not been worked long enough to decide what measure of success may be expected, but the results are watched with great interest, although without very much expectation of commercial success. An experiment on the over-oxidation of steel in the Bessemer converter discovered the wholly unexpected difficulty of making metal absorb more than 0.075 per cent. of oxygen.

LEAD

By H. B. Coho

An estimate of the production of refined lead in the United States in 1913 has been compiled by C. E. Siebenthal, of the United States Geological Survey, from reports made by all lead refineries and soft-lead smelters in operation during the year. The statistics of imports, exports, and lead remaining in warehouse have been taken from the records of the Bureau of Foreign and Domestic Commerce.

During the year three new lead furnaces were completed at the smelter of the International Smelting & Refining Co. at Toole, Utah, giving the plant a capacity of 1250 tons daily. The Balbach Smelting & Refining Co. removed its lead refinery from the former location to a new site on Newark Bay and doubled its equipment and capacity. It is reported in the mining press that a 100-ton lead stack is to be built in the Warren district of Arizona to handle the output of the Shattuck mine.

Production

The total production of refined lead, desilverized and soft, from domestic and foreign ores in 1913 was approximately 462,460 short tons, worth at the average New York price, $41,082,184, compared with 480,894 tons, worth $43,280,460, in 1912 and 486,979 tons in 1911. These figures do not include an estimated output of 16,338 tons of antimonial lead, against 13,552 tons in 1912 and 14,078 tons in 1911. Of the total production, desilverized lead of domestic origin, exclusive of desilverized soft lead, is estimated at 256,458 tons, against 221,480 tons in 1912; and desilverized lead of foreign origin at 54,372 tons, compared with 88,377 tons in 1912. The production of soft lead, mainly from Mississippi Valley ores, is estimated at 156,013 tons, compared with 171,037 tons in 1912.

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES.
(Refinery Statistics. In tons of 2000 lb.)

Year.	Domestic Origin.						Foreign Origin.		Grand Total.
	Desilverised.	Antimonial	S. E. Mo.	S. W.Mo.	Miscel.	Total.	Desilverised.	Antimonial	
1908...	174,650	13,109	113,103	18,014	*Nil.*	318,876	94,992	(a)	413,868
1909...	211,499	10,392	126,784	20,489	*Nil.*	369,164	89,681	2,338	461,183
1910(b)	217,490	9,098	145,387	20,729	*Nil.*	392,704	90,473	4,892	488,069
1911(b)	211,041	8,916	155,008	25,993	*Nil.*	400,958	89,487	4,929	495,374
1912(b)	236,207	9,239	145,336	19,224	*Nil.*	410,006	82,715	5,003	497,724
1913(b)	261,616	16,345	133,203	22,312	*Nil.*	433,476	54,774	2,300	490,550

(a) Entered under domestic antimonial. (b) From *Eng. Min. Jour.*

The final figures of production of soft lead are likely to show an increase of a few thousand tons over those here given, for the reason that the argentiferous lead smelters and refineries undoubtedly treated more or less soft lead from the Mississippi valley which is not distinguished from silver-lead ores in their preliminary estimates. It may be, with these additions, that Missouri will retain first place in the year's output of refined lead. In the mine production of lead, Missouri lost first place to Idaho. There was a marked falling off in the production of desilverized lead to foreign origin, owing to the disturbed conditions in Mexico, but this loss was more than made up by the increased output of domestic lead.

STATISTICS OF LEAD IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Produced from Domestic Ores.				Imported in Ores and Bullion. (c)	Total Production and Imports.	Exported. (c)
	Desilverised.	Soft. (a)	Antimonial. (b)	Totals.			
1900....	221,278	47,923	9,906	279,107	114,397	425,824	100,288
1901....	211,368	57,898	10,656	279,922	112,471	458,033	100,026
1902....	199,615	70,424	10,485	280,524	107,715	458,456	82,228
1903....	188,943	78,298	9,453	276,694	106,407	418,601	81,971
1904....	200,858	90,470	10,876	302,204	112,852	415,056	84,142
1905....	205,665	105,623	11,186	322,474	98,378	420,852	59,741
1906....	220,095	118,000	10,120	348,215	84,134	432,349	47,323
1907....	213,383	127,133	9,614	350,130	79,815	429,945	51,502
1908....	174,650	131,117	13,109	318,876	112,074	430,950	76,857
1909....	211,499	147,273	12,730	371,502	114,181	485,683	86,077
1910(d).	217,490	166,116	13,990	397,596	108,602	506,198	69,786
1911(d).	211,041	181,001	13,845	405,887	89,951	495,838	101,787
1912(d).	236,207	164,560	14,242	415,009	83,560	498,569	64,905
1913(d).	261,616	155,515	18,645	435,876	57,146	493,022	44,544

(a) Since 1904 a large part of the so-called soft lead was desilverised, but this (being of Missouri origin) has been included in the old classification. (b) The entire production of antimonial lead is entered as of domestic production, although part of it is of foreign origin. (c) Includes "pigs, bars and old but not manufactures." (d) From *Eng. Min. Jour.*

Imports and Exports

The imports of lead for the year 1913 are reported as 9967 short tons of lead in ore, valued at $496,514; 47,164 tons of lead in base bullion, valued at $2,465,625; and 41 tons of refined lead, valued at $3678—a total of 57,146 tons, compared with 83,560 tons in 1912. Of the 1913 imports, 47,000 tons, or about 83 per cent., came from Mexico; over 4000 tons from German East Africa, and the remainder chiefly from South America. The exports of foreign lead (lead of foreign origin smelted or refined in the United States) show a decrease of about a third, being estimated at 51,214 tons, against 76,226 tons in 1912. The imports of type metal (antimonial lead) were 554,749 lb., containing 457,466 lb. of lead and valued at $19,869, all imported in the first half of the year. During the second half of the year lead has been so

nearly on a parity with foreign lead that it was not profitable to import foreign material on which duty must be paid.

IMPORTS OF LEAD, IN ORE, BASE BULLION, AND REFINED, BY COUNTRIES, 1908–1913, IN POUNDS.

Country.	1908.	1909.	1910.	1911.	1912.	1913.
United Kingdom	399,569	191,243	1,874,750	401,686	279,546	404,594
Germany	695,151	2,821,967	421,377	56,286	494,237	262,132
Other European countries.	1,699,509	1,385,616	418,669	111,189	55,356	143,293
British North America.	1,291,044	4,133,755	206,979	270,947	319,497	334,194
Mexico	219,567,193	215,203,714	203,290,307	172,633,479	159,455,664	95,693,439
South America	469,770	1,942,847	6,598,263	4,778,221	3,207,936	8,766,327
Other countries	26,418	2,683,950	4,394,421	1,651,544	3,309,365	8,685,612
Total imports	224,148,654	228,363,092	217,204,766	179,903,352	167,121,592	114,289,561

IMPORTS OF LEAD, BY CLASSES, 1907–1912, IN POUNDS.

Year.	Lead in Ore (Lead Content).	Base Bullion.		Pigs, Bars, Sheets, and Old.	Total Lead Content.[1]
		Gross Weight.	Lead Content.[1]		
1907	64,815,254	76,259,828	74,594,313	18,554,899	157,964,466
1908	64,708,204	153,921,829	150,560,176	5,518,621	220,787,001
1909	71,357,868	149,852,559	146,579,779	7,152,665	225,090,312
1910	94,751,054	118,061,415	115,483,542	6,970,170	217,204,766
1911	35,686,180	141,481,852	138,952,372	5,264,800	179,903,352
1912	19,577,499	152,420,624	146,999,168	544,925	167,121,592
1913	17,616,783	96,908,170	94,327,654	78,624	114,289,591

[1] Lead content of bullion for 1907–1909 estimated on the basis of average lead content of imports of base bullion in 1910.

Lead Available for Consumption

The amount of lead available for consumption during 1913 may be estimated by adding to the stock of foreign lead (domestic stocks are not known) in bonded warehouses at the beginning of the year (10,492 short tons) the imports (57,145 tons) and the domestic production (410,878 tons), making an apparent supply of 479,515 tons. From this is to be subtracted the foreign lead exported from warehouse (44,544 tons), the foreign lead exported in manufactures under drawbacks (9757), the deduction by liquidation (419 tons), and the stock in bonded warehouses at the close of the year (5310 tons), leaving as available for consumption 419,485 tons, which by comparison with 388,148 tons in 1912, with 385,319 tons in 1911, and 379,196 tons in 1910 seems to be an excessive figure, making it seem very probable that in lead, as in zinc, there has been a large increase in smelter stocks. The relatively high price of lead in Europe induced the exportation of lead of foreign origin faster than it was smelted and refined in this country, as shown above by the decrease of stocks in bonded warehouses from 10,492 tons, January 1 to 5310 tons December 31, showing that the increase in smelter stocks was made up wholly of domestic lead. The foreign lead remaining in warehouse at

the close of 1913, was distributed as follows: At El Paso, 842 short tons; at St. Louis, 36 tons; at Chicago, 40 tons; at New York, 4393 tons.

LEAD PRODUCTION OF THE WORLD.
(In metric tons.)

Year.	Australasia. (a)	Austria. (a)	Belgium (a)	Canada (a)	France. (a)	Germany (a)	Greece. (a)	Hungary (a)	Italy. (a)
1900	87,100	10,650	16,365	28,648	15,210	121,513	16,396	2,030	23,673
1901	90,000	10,161	18,760	23,537	21,000	123,098	17,644	2,029	25,796
1902	90,000	11,264	19,504	10,411	18,817	140,331	14,048	2,243	26,494
1903	106,006	12,162	22,263	8,226	23,258	145,319	12,361	2,057	22,126
1904	117,895	12,645	23,470	17,241	18,800	137,580	15,186	2,104	23,475
1905	106,418	12,968	22,885	25,391	24,100	152,590	13,729	2,146	19,097
1906	93,557	14,846	23,765	24,580	25,614	150,741	12,308	1,925	21,268
1907	96,608	13,598	27,450	21,660	24,800	164,079	13,814	1,468	22,978
1908	119,207	12,669	35,650	19,593	26,112	164,079	15,892	1,544	26,003
1909	77,992	12,941	40,306	23,295	26,927	167,920	14,948	1,590	22,133
1910	105,897	15,476	40,715	14,967	20,226	159,851	16,710	2,077	14,495
1911	105,397	18,097	44,308	10,791	23,635	161,287	14,234	1,583	16,684
1912	113,710	19,993	54,940	16,226	31,080	192,618	14,498	1,605	21,450
1913	.....	22,312	35,750	17,089	.....	.....	.....	.....	.....

Year.	Japan. (a)	Mexico. (a)	Russia. (a)	Spain. (a)	Sweden. (a)	United Kingdom. (a)		United States.	Totals. (f)
						Foreign Ores.	Domestic Ore.		
1900	1,877	63,827	221	172,530	1,424	10,738	24,762	253,204	849,168
1901	1,806	94,194	156	169,294	988	19,639	20,361	253,944	892,407
1902	1,644	106,805	225	177,560	842	9,113	17,987	254,682	901,970
1903	1,728	(b) 94,181	106	175,109	678	14,900	20,278	256,138	916,896
1904	1,803	(c) 95,010	90	185,862	589	6,888	20,155	278,634	957,427
1905	2,272	(b)101,196	700	185,693	576	7,517	20,977	290,472	988,727
1906	4,305	(b) 73,699	907	185,470	753	6,984	22,691	323,567	986,980
1907	3,067	(b) 76,158	520	(d)185,800	813	10,880	24,850	322,854	1,010,605
1908	2,910	(b)127,010	523	188,062	277	11,480	21,336	284,858	1,057,205
1909	3,429	(b)118,186	(d) 790	179,993	166	8,056	22,822	(g)334,832	1,056,326
1910	3,907	(b)120,662	(d)1,200	190,523	355	8,933	21,866	(g)355,183	1,093,144
1911	4,160	(b)124,605	(d)1,000	189,810	1,134	10,048	18,278	(g)363,829	1,069,289
1912	3,613	(b)109,717	.....	232,612	1,073	(e) 8,255	17,806	(g)372,056	.....
1913	.....	(b) 55,530	.....	.....	1,235	.....	.....	(g)395,358	.....

(a) From official reports of countries unless otherwise denoted. (b) Exports. (d) As reported by Metallgesellschaft, Frankfurt am Main. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated. (g) From *Eng. Min. Jour.*

The Lead Market in 1913

The year 1913, in the lead market, is of more than passing interest, as with the passing of the new tariff law, the conditions which made the American lead market practically independent of those of the rest of the world, were partially broken down, and the reduction in the duty of approximately 70 to 25 per cent. ad valorem will mean that the American lead market will be sensitive and greatly influenced by the lead market of the rest of the world.

The American market was greatly affected by the political disturbances in Mexico, as a large percentage of the Mexican production of lead was withheld from the European market, causing a scarcity of lead

abroad, and forcing prices considerably above the average for the past 10 years. Due to this cause the importation of lead was greatly curtailed in spite of the reduction in the tariff.

On Jan. 1, 1913, lead opened at 4.15 St. Louis and about 4.30 New York. These prices were considered low and buying of considerable magnitude developed, as consumers felt that in comparison with prices ruling during the summer of 1912, the price of 4.30 New York was exceptionally low. The market remained firm around 4.30 New York until April, 1913, when continuing demand and lessening supply forced the price to 4.50 N. Y.

Outside sellers took advantage of the higher price to dispose of their production, at a figure slightly below the schedule of the American Smelting & Refining Co. with the result that the A. S. & R. again reduced their price about the beginning of May to 4.35 N. Y., at which level the price of lead was maintained until the end of July.

About the end of July, 1913 rumors of labor troubles in southeastern Missouri became current and sellers became reluctant to make commitments, with the results that the market became very strong, and the price advanced to 4.50 N. Y. basis, and when the strike was declared on Aug. 15 the market advanced to 4.75 N.Y.

In the experience of the oldest lead men, no more unusual condition ever developed in the history of that metal, than that in August, 1913, when the curtailed deliveries of southeastern Missouri established prices in St. Louis at the New York level, and at times lead in Missouri was higher than in New York.

The strike was adjusted in September, and outside sellers readily took business below the price asked by the American Smelting & Refining Co. The latter met the attack by reducing its price in rapid succession from 4.60 on Oct. 1 to 4.35 on Oct. 16, New York delivery.

The unsettled condition in prices during October made consumers reluctant to place large orders and buying was largely for current requirements, and quantities of lead were obtainable at considerable concessions from quoted prices. On Nov. 26 the price dropped to 4.25 which was quickly followed by further reductions, the price Dec. 2 being 4.10 and Dec. 9, 4 cents.

The price of 4 cents N. Y. must be considered a low one, not only in consideration of the European market, but since it approaches dangerously near the cost of production, as it is pretty well known that some of the largest mines in the country cannot produce lead at 4 cents and make a legitimate profit. The demand for lead during November and December is never very brisk, but speculators took advantage of the price to buy at the market.

With the exception of the A. S. & R. the producers withdrew from the market with the result that the A. S. & R. were flooded with orders and were forced to advance their price, which was established at 4.10 on Dec. 24 and 4.15 on Dec. 29. The year closed with the market firm at the latter figure for N.Y. delivery and 4.05 to 4.10 for St. Louis.

The London Lead Market in 1913[1]

January.—The market throughout was sensitive to political influences, and the speculative element tended to depress values. Opening at a fractional decline, soft foreign was quoted £18 per ton, and drifted downward till the 17th, when £16 1/2 was accepted. A recovery to £17 1/4 was of short duration, though trade was normally good. The month closed with £16 1/2 again ruling.

February.—An early recovery up to £17 was followed by a gradual relapse, which continued with little intermission till the end of the month. Consumers bought cautiously, and full prices were paid only for prompt delivery. The close was quiet at £16 1/8 at £16 1/4.

March.—The market remained unchanged for a few days and then developed sudden weakness, due to large arrivals in London, whereby prices were depressed to £15 3/8 for foreign brands. This attracted some demand, particularly from the continent, and values improved gradually closing quotation being £16 3/8 at 16 7/8.

April.—Opening prices were unchanged, but a gradual and persistent advance began on the following day and culminated on the 15th, when £18 15/16 was paid for April delivery, £18 being accepted for August. Thereafter the tension was relieved by better news from the producing centers and by the approach of incoming supplies. Prices ceased with occasional fluctuation and closed at £17 3/4 for early delivery, and £17 1/4 for forward delivery.

May.—Values were unaltered at the opening but advanced persistently until the close, when £19 7/8 was quoted for early delivery and down to £19 1/4 for deliveries extending into August.

June.—Scarcity of available supply produced a wide divergency between the price ruling for early and later delivery. This culminated on the 23rd, when £20 1/2 was paid for prompt delivery, while September delivery commanded only £18 1/4. The ultimate trend of prices was downward, but not to the same extent as in the other commercial metals. For prompt delivery the highest paid was £21 1/2, and the lowest £19 1/4; for later delivery the highest was £19 1/2, and the lowest £18, closing values being £19 1/2 and £18 1/4, respectively.

[1] *Eng. Min. Jour.*

July.—The premium for prompt delivery varied from £1 to £1 1/2. The market was active throughout, speculators participating freely. The lowest values ruled on the 7th, when markets generally were depressed by outside influences; £19 1/4 being accepted for early delivery, and £18 1/4 for forward. Thereafter the trend was upward, the highest being reached on the 29th, viz., £21 1/4 and £19 3/4, respectively, closing at £20 3/4 and £19 3/4 respectively.

August.—Scarcity of available supply was again the dominating feature of the month, spot parcels at one time commanding a premium of £2 per ton. The relative cheapness of forward delivery attracted buyers as the month advanced, and the difference in value narrowed accordingly, occasionally to 15s. Trade for home and export was continuously brisk. Opening prices were £20 5/8 for early delivery, down to £19 1/2 for forward. The lowest was recorded on the 12th, being £20 1/2 and £18 1/2, respectively. The close was at £20 1/4 and £19, respectively.

September.—Opened with a sharp rally in values to £20 3/4 for early delivery and £19 1/2 for later. Fluctuations were numerous and irregular throughout the month, but the underlying conditions remained unaltered with available supplies very meager, the premium for the latter varying between 20 and 30s.

October.—Grave news from Mexico, together with a better export demand were enough to keep values firm almost throughout, and lead closed at £20 5/8 for near metal with forward at about 25s. discount.

November.—Continued demand from Russia and labor troubles at the mines in Spain did not prevent values from falling to £18 for near stuff and £17 3/8 for forward.

December again saw lower prices despite a slight revival in demand from the electrical users, "bear" covering and further purchases for Russian account. The closing price was £18 1/8 for spot lead.

AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
1899...	4.18	4.49	4.37	4.31	4.44	4.43	4.52	4.57	4.58	4.58	3.70	4.64	4.47
1900...	4.68	4.68	4.68	4.68	4.18	3.90	4.03	4.25	4.35	4.35	4.58	4.35	4.37
1901...	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.15	4.33
1902...	4.00	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.069
1903...	4.075	4.075	4.442	4.567	4.325	4.210	4.075	4.075	4.243	4.375	4.218	4.162	4.237
1904...	4.347	4.375	4.475	4.475	4.423	4.196	4.192	4.111	4.200	4.200	4.200	4.600	4.309
1905...	4.552	4.450	4.470	4.500	4.500	4.500	4.524	4.665	4.850	4.850	5.200	5.422	4.707
1906...	5.600	5.464	5.350	5.404	5.685	5.750	5.750	5.750	5.750	5.750	5.750	5.900	5.657
1907...	6.000	6.000	6.000	6.000	6.000	5.760	5.288	5.250	4.813	4.750	4.376	3.658	5.325
1908...	3.691	3.725	3.838	3.993	4.253	4.466	4.477	4.580	4.515	4.351	4.330	4.213	4.200
1909...	4.175	4.018	3.986	4.168	4.287	4.350	4.321	4.363	4.342	4.341	4.370	4.560	4.273
1910(a	4.700	4.613	4.459	4.376	4.315	4.343	4.404	4.400	4.400	4.400	4.442	4.500	4.446
1911(a	4.483	4.440	4.394	4.412	4.373	4.435	4.499	4.500	4.485	4.265	4.298	4.450	4.420
1912(a	4.435	4.026	4.073	4.200	4.194	4.392	4.720	4.569	5.048	5.071	4.615	4.303	4.471
1913(a	4.321	4.325	4.327	4.381	4.342	4.325	4.353	4.624	4.698	4.402	4.293	4.047	4.370

(a) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF LEAD PER 2240 LB. AT LONDON. (a)
(In pounds sterling.)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1899....	13.375	14.350	14.150	14.375	14.146	14.283	14.385	14.733	15.267	16.179	17.096	16.883	14.933
1900....	16.296	16.542	16.612	16.733	16.900	17.225	17.533	17.633	17.667	17.596	17.229	16.233	16.987
1901....	15.925	14.667	13.379	12.421	12.275	12.342	12.150	11.692	11.954	11.600	11.267	10.533	12.521
1902....	10.567	11.617	11.508	11.596	11.600	11.271	11.233	11.121	10.892	10.746	10.717	10.754	11.262
1903....	11.304	11.708	13.225	12.404	11.800	11.437	11.383	11.146	11.167	11.108	11.108	11.179	11.579
1904....	11.558	11.592	12.037	12.254	11.754	11.521	11.667	11.737	11.787	12.187	12.892	12.775	11.983
1905....	12.875	12.462	12.296	12.658	12.762	13.000	13.608	13.958	13.950	14.679	15.337	17.050	13.719
1906....	16.850	16.031	15.922	15.959	16.725	16.813	16.525	17.109	18.266	19.350	19.281	19.609	17.370
1907....	19.828	19.531	19.703	19.975	19.688	20.188	20.350	19.063	19.775	18.531	17.281	14.500	19.034
1908....	14.469	14.250	13.975	13.469	12.938	12.600	13.000	13.375	13.125	13.375	13.538	13.156	13.439
1909....	13.113	13.313	13.438	13.297	13.225	13.031	12.563	12.475	12.781	13.175	13.047	13.125	13.042
1910....	13.650	13.328	13.063	12.641	12.550	12.688	12.531	12.513	12.582	13.091	13.217	13.197	12.920
1911....	13.009	13.043	13.122	12.889	12.984	13.260	13.530	14.260	14.744	15.332	15.821	15.648	13.970
1912....	15.597	15.738	15.997	16.331	16.509	17.588	18.544	19.655	22.292	20.630	18.193	18.069	17.929
1913....	17.114	16.550	15.977	17.597	18.923	20.226	20.038	20.406	20.648	20.302	19.934	17.798	18.743

(a) The statistics for 1897–1905 are from the report of the Metallgesellschaft, Frankfurt-am-Main Those for subsequent years are from the *Eng.Min. Jour.*

White Lead and the Oxides

More than 25 per cent. of the pig lead consumed in the United States finds its outlet through white lead and the oxides. These products have not increased in consumption of later years in the same ratio as some of the mechanical products of lead, notably those for which the demand has been created by the development of the electrical industry, but their increase has been proportional to the increase of population, and even if there has been some shifting of the channels of consumption, the aggregate has kept pace with the growth of the country.

White lead in its dry form has been largely displaced in some of the manufacturing industries by cheaper materials, such as zinc, lithopone and barytes, but in the paint industry, while it has met the competition of these cheap pigments, it has more than held its own. This has been due in part to the influence which paint legislation has had in improving the quality of many of the prepared paints, all of which derive their chief paint value from the white lead they contain. Attempts to enact laws compelling the publication of formulas on paint labels, although unsuccessful in most states, resulted in such an agitation of the subject, and in so much publicity being given to the worthless character of some of the compounds branded as paint, some of them masquerading as pure white lead paint, that the public demanded better goods. As a result the sale of this class of paints has been more largely diverted to the higher grades, and an equal number of gallons of the prepared paints sold to-day would carry probably 20 per cent. more white lead than the same number of gallons would have contained 10 years ago. In this outlet white lead, by which is meant lead carbonate, has met the competition of basic lead sulphate to some extent, but the aggregate sales of the former as mixed paint are undoubtedly greater to-day than ever before.

In straight white lead paint, made from the paste which is known as "white lead in oil," there has been a steady growth of consumption which has been more than proportionate to the growth of population during the past 10 or 15 years. While this may be accepted as evidence that white lead holds its place in the public estimate of its value as a paint pigment, it is also due in a measure to the fact that there is more painting done in this country than formerly. The great consumption of white lead paint is for exterior work, and a tour through almost any section of the country where there are paintable structures will show that more attention is given each year to the better appearance as well as to the protection which painting affords.

The year 1913 showed a moderate increase in the sales of white lead, both dry and in oil, over those of the preceding year. There was a shady gain during the first 9 months, but a portion of this was lost in the last quarter, without any very apparent reason for the falling off, which was especially heavy in October. These were from price changes, and then followed wide fluctuations in pig lead.

White lead in oil opened at a minimum price of 6 3/4 cents, advanced to 7 1/4 cents in August and again declined to 6 3/4 cents, which is the closing figure. These are carload prices, with the usual advances of 1/4 cent to 3/4 cent for smaller quantities.

The fluctuations in prices on oxides have corresponded closely with those on white lead, but there has been less stability to prices, owing to active competition among domestic makers. Consumers are not quite so exacting regarding either the brand or quality of red lead and litharge, as they are with white lead, and price is, therefore, a more influential factor. Red lead has been offered during the year as low as 5 3/4 cents against a minimum of 6 1/4 cents for the standard makes, and litharge at 5 1/4 cents against 5 1/2 cents. For makes which would be accepted generally, the price of red lead during the year has ranged from 6 1/4 to 6 3/4 cents as to quantity, and for litharge from 5 1/2 to 6 1/4 cents. The demand for red lead now runs very largely in the grades running 94 to 96 per cent. true red lead, the lower percentages bring the minimum standard fixed by the government for its purchases, and subsequently adopted by many of the railroads and other large consumers, and by engineers and architects in their specifications. For many uses the old commercial grades running from 85 to 90 per cent. true red lead, are still satisfactory, and some engineers claim that these grades, containing 10 to 15 per cent. of litharge are preferable for structural work to those running higher in true red lead. This phase of the subject has been widely discussed of late, and while the different opinions find support in the various "tests" that have been made, the consensus of opinion is in favor of a high degree of oxidation and a

red lead running as high as 99 per cent. is now being marketed and finds favor with engineers who have given close attention to the protective qualities of red lead on steel and iron.

Makers of red lead and litharge were somewhat apprehensive that the reduction in duty under the new tariff would open the door to competition from Great Britain and Germany, but thus far this has been averted during the entire year. Foreign makers of oxides are not only operating at a lower manufacturing cost than obtains in this country, but with lower sales expense, a lower rate of interest and less overhead changes of all sorts. This enables them to operate on a smaller margin between the cost of pig lead and the price of their finished product, than is possible in this country, and with pig lead on a parity with London at the average price for 20 years prior to 1913 plus duty, the duty of 25 per cent. on oxides would not be sufficient to equalize prices. In other words, 25 per cent. duty on the difference between the cost of pig lead and oxides in the foreign market with freight added, would not be sufficient to offset the excess in the differenc in cost of manufacturing and selling here. A settlement of the Mexican troubles and renewal of supplies of lead from that country, with a consequent return to the lower level of prices for pig lead in European markets, would be likely to open this market to foreign competition in many lead products. This is less to be feared on white lead, on which the two markets are always nearer a purity, than on oxides. The saving clause on the latter, however, is to be found in the fact that much of the commercial red lead in Great Britain would not be accepted by consumers here, because it is very inferior to the domestic product both in color and texture. The same is true of litharge, but the importation of the latter is not threatening, in view of the fact that there is less difference in quality or price between foreign red lead and litharge than there is in the American products.

PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES.

Year.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short Tons	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1899...	10,199	$1,070,895	103,466	$10,812,197	10,020	$1,032,060	928	$ 139,200
1900...	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650
1901...	13,103	1,448,550	100,787	11,252,653	9,460	979,586	1,087	224,667
1902...	11,669	1,262,712	114,658	11,978,172	12,755	1,299,443	867	138,349
1903...	12,300	1,385,900	112,700	12,228,024	12,400	1,326,800	1,000	168,000
1904...	13,938	1,672,569	126,336	13,896,913	12,487	1,248,691	1,125	168,681
1905...	16,269	1,919,767	122,398	12,068,443	12,643	1,422,616	1,000	120,000
1906...	13,693	1,874,448	123,640	15,234,990	13,816	1,890,050	2,927	421,488
1907...	13,370	1,778,717	111,409	12,254,297	14,769	1,624,553	815	123,917
1908...	11,358	1,156,282	116,628	10,515,315	12,254	1,231,206	393	43,157
1909...	15,800	1,438,197	131,643	12,652,638	13,391	1,266,903	530	68,003
1910 (b)	16,116	1,482,672	134,276	13,024,762	13,659	1,283,940	541	70,330
1911 (b)	19,594	2,345,520	132,612	17,393,241	25,190	2,733,196	766	119,370
1912 (b)	21,120	2,571,702	146,833	18,683,461	29,111	3,194,194	545	88,245

(a) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included in 1904–10. (b) U. S. Geol. Surv.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES.

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1899.....	776,197	$30,479	583,409	$30,212	55,127	$3,614	1,141,387	$58,142
1900.....	549,551	25,532	456,872	28,336	77,314	2,852	1,068,793	61,885
1901.....	485,466	19,369	384,671	21,226	49,306	1,873	977,644	52,409
1902.....	1,075,839	37,833	506,423	25,320	88,115	2,908	997,494	49,060
1903.....	1,152,715	40,846	453,284	24,595	42,756	1,464	756,742	36,407
1904.....	836,077	30,115	587,383	33,788	44,541	1,500	766,469	37,178
1905.....	704,402	26,553	597,510	34,722	117,759	4,139	628,003	31,106
1906.....	1,093,619	50,741	647,636	41,233	87,230	3,737	770,342	42,519
1907.....	679,171	35,959	584,309	37,482	90,475	4,386	615,015	37,799
1908.....	645,073	28,155	540,311	30,451	96,184	3,327	485,407	26,645
1909.....	760,179	30,428	694,599	39,963	90,655	3,740	496,231	27,562
1910.....	822,289	32,750	686,052	38,919	48,693	2,252	600,461	32,199
1911.....	1,163,533	46,170	741,071	46,213	24,662	1,196	504,734	28,515
1912.....	757,908	33,854	687,705	46,494	32,443	1,550	334,551	20,914
1913.....	145,478	7,223	679,078	46,527	34,022	1,649	287,535	18,595

Lead Poisoning

The importance of lead poisoning among the recognized occupational diseases has been exaggerated by the recklessness with which physicians, having a patient who has ever worked in any industry where lead is handled, have diagnosed as plumbism any case showing any of the symptoms typical of that disorder, although they might be equally characteristic of a dozen other diseases of quite distinct origin. The records of hospitals and state and local Boards of Health have, therefore, afforded statistics that have caused all industries in which lead is handled, to be regarded as more dangerous to health than facts would justify. Beyond question, the handling of lead in any form may be a menace to health if the ordinary rules of cleanliness are disregarded, but there is no form in which the danger may not safely be avoided if the obvious precautions are taken. Probably the exaggerations of sensational writers and speakers upon this subject have accomplished some good in bringing lead workers, no less than their employers, to realize the hazards of the industry, and at the same time making them recognize the necessity and effectiveness of individual caution. The larger lead manufacturing industries have, during the last few years, practically eliminated the hazard in so far as it can be done by mechanical devices, medical examinations and primitive regulations, and with intelligent coöperation, or implicit observance of regulations on the part of workmen, employment in these industries no longer need be regarded as hazardous. The number of cases of lead poisoning reported in any of the states where records are kept, has been greatly reduced, and even among painters and printers, who have been the hardest to reach of any classes of workmen exposed to lead poisoning, the agitation of the subject has led to a degree of personal cleanliness and care in the handling of materials that have brought these trials much nearer to the point of absolute safety which might easily be

attained with a still more strict observance of plainly indicated precautions. There are so many industries in which lead is a material for which there is no substitute, that a prohibition of its use, even if it were justified, would be an economic absurdity, but the elimination of the dangers attending its use is just as practicable and no more difficult than the elimination of the hazards attending the use of unprotected machinery, and manufacturers are recognizing both the humanitarian and the economic value of such safeguards to the lives and health of their employes.

Lead Mining in the United States

The following table shows the production of lead according to the source of the ore, as given by the U. S. Geological Survey. These figures are of course considerably less, in most cases, than the mine production; wherever important differences occur, both figures will be given if they are available.

PRIMARY LEAD SMELTED OR REFINED IN THE UNITED STATES.
(Apportioned according to source of ore.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Domestic Ore:								
Alaska	8	.....	3	69	75	51	45	6
Arizona	2,884	2,418	1,464	1,507	948	3,428	3,891	4,901
Arkansas	.....	15	.....	14	.....	15	.....	.....
California	432	938	515	977	1,207	615	811	3,202
Colorado	50,497	52,552	28,729	30,865	38,542	30,442	37,039	42,844
Idaho	117,117	123,292	98,464	103,747	109,951	117,335	127,780	137,809
Illinois	572	498	362	273	263	308	513	619
Iowa	270	225	110	15	.....	.....	.....	.....
Kansas	1,932	1,798	2,293	2,763	1,308	2,522	1,937	1,504
Kentucky	44	75	.....	.....	50	.....	91	16
Missouri	111,075	122,856	122,451	141,105	161,659	182,203	162,610	152,430
Montana	2,485	2,145	2,320	1,451	1,943	2,484	2,517	3,256
Nevada	1,669	3,480	3,796	4,792	2,246	1,082	5,699	6,142
New Mexico	640	2,047	586	1,350	1,890	1,371	2,511	1,821
North Carolina	.....	.....	.....	.....	2	35	34	10
Oklahoma	.....	404	1,409	2,268	1,805	1,925	2,500	3,214
Oregon	.....	5	7	7	.....	11	21	37
South Dakota	.....	.....	13	.....	8	33	12	7
Tennessee	11	16	.....	.....	.....	.....	.....	.....
Texas	25	12	42	44	36	57	30	108
Utah	56,260	55,540	42,455	66,648	60,605	54,933	60,664	71,069
Virginia	.....	83	13	.....	87	400	85	878
Washington	46	341	391	120	339	612	53	9
Wisconsin	1,753	3,573	4,013	3,252	3,909	3,966	3,301	2,639
Undistributed	380	896	36	317	101	48	120	63
Zinc residues	2,053	1,890	1 290	1,735	2,237	1,987	3,131	3,765
Total from domestic ore	350,153	375,099	310,762	363,319	389,211	405,863	415,395	436,430
Foreign Ore:								
Africa	.....	288	.....	3,150	3,310	582	1,774	5,976
Canada	7,238	2,607	162	66	25	122	29	16
Central America	112	23	12	20	3	28	.....	.....
Mexico	21,435	20,204	10,145	16,944	11,704	7,333	7,407	4,512
South America	.....	919	1,186	1,536	2,996	2,677	2,332	2,617
Other foreign	18	.....	4	38	27	22	30	102
Foreign Base Bullion:								
Canada	.....	2,716	179	1,500	.....	.....	.....	.....
Mexico	39,743	34,251	73,210	70,816	76,805	84,220	76,805	37,359
Total from foreign ore and base bullion.	68,546	61,008	84,898	94,070	94,870	94,984	88,377	50,582
Grand total, derived from all sources.	418,699	433,260	395,660	457,389	484,081	500,847	503,772	487,012

Arizona.—The lead production from Arizona for 1913 amounted to 4,901 tons, an increase of about 1,000 tons over the previous year. The lead was obtained chiefly from the mines at Bisbee. The Tennessee mine in Mohave County was also an important producer.

California.—The California production showed a marked increase to 3294 tons. The chief producing county is Inyo, followed by San Bernardino, Mono, and Kern Counties. A number of other counties furnish small amounts.

Colorado.—The lead production in Colorado in 1913 increased to 42,840 tons, an increase of about 15 per cent. over the 1912 figures. The following table shows the distribution of the production.

LEAD PRODUCTION OF COLORADO.(a)
(In tons of 2000 lb.)

County.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913. (c)
Clear Creek..	1,631	1,439	1,832	1,205	1,495	1,228	1,956	2,423	2,160
Hinsdale.....	446	442	470	82	50	124	60	611	410
Lake.....	26,424	23,918	17,032	7,169	7,061	6,364	8,119	12,368	14,000
Mineral.....	5,940	7,443	6,490	4,119	4,526	4,066	3,501	2,634	1,780
Ouray.....	2,674	2,861	1,803	1,516	1,354	2,021	2,002	1,531	1,200
Pitkin.....	10,987	8,781	6,957	3,713	6,315	6,704	5,090	4,195	8,390
San Juan....	3,223	2,070	6,213	5,133	4,921	5,444	3,140	4,452	14,900
Others.....	6,531	6,038	5,696	5,918	6,638	3,332	8,891	8,475	
Total.....	57,856	52,992	46,493	28,855	32,360	35,283	32,759	36,689	42,840

(a) As reported by the State Commissioner of Mines.

It has become increasingly apparent that Colorado producers of lead and zinc can, as a rule, make money only when prices are high, unless the zinc and lead are regarded merely as by-products in the mining of gold and silver.

The Iron-Silver Co. and Yak Tunnel have shipped low-grade lead-silver ores extensively. At Breckenridge, the Wellington has shut down its wet-concentrating mill, partly on account of low metal prices, partly because of increased freight rates and exhaustion of the best lead-carrying ore-bodies. The Iron Mask at Red Cliff, the Tomboy at Telluride, the Sunnyside at Silverton and the Mary Murphy at St. Elmo have all becn active shippers of zinc and lead concentrates, the first from magnetic separators and the last two from electrostatic plans using Huff machines.

The Leadville district yielded a large part of the lead output of the state. The Aspen district doubled its lead output and the Rico district made large gains in both lead and zinc. The San Juan district of Dolores, La Plata, Ouray, San Juan and San Miguel Counties showed a slight increase in production, a considerable increase in Dolores County overbalancing a decrease in San Miguel and Ouray Counties. Chaffee County also showed a considerable increase. The output at Creede

showed an appreciable decrease, as well as that of Hinsdale and Gunnison Counties.

Idaho.—The lead production of Idaho for the year 1913 was 137,802 tons, an increase of about 10,000 tons over the preceding year. The mine production of metal amounts to considerable more than this, about 155,500 tons, making the state first in mine production, but still second to Missouri in smelter production. About 90 per cent. of the lead output of the state comes from the Cœur d'Alene, and the increased production largely due to increased activities in the mines in that region.

For 1913 the Cœur d'Alenes[1] show a yield in lead, silver and zinc greater than any preceding year; there was a falling off in copper alone. But more important than this record production is the successful exploration work done in large measure in the old mines and in the new properties. There are more producing mines in the Cœur d'Alenes now than ever before, as follows:

Federal Mining & Smelting Co.
Hercules Mining Co.
Bunker Hill & Sullivan Mining & Concentrating Co.
Hecla Mining Co.
Green Hill Cleveland Mining Co.
Stewart Mining Co.
Snowstorm Mining Co.
Interstate-Callahan Consolidated Mining Co.
Success Mining Co.
Tamarack & Custer Consolidated Mining Co.
Caledonia Mining Co.
Gold Hunter Mining Co.
Ontario Mining Co.
Sierra Nevada Consolidated Mining Co.
Marsh Mining Co.
Idora Hill Mining Co.
Hypotheck Mining Co.

The Yankee Boy, Alice, and mines of the Cœur d'Alene Development Co. are operated under lease, and there are mills on the Black Horse, Monarch, Bear Top and Surprise mines which have made periodic production. The National Mining Co. is making good progress in the erection of a most modern concentrator for the treatment of its well-developed large body of silver-bearing disseminated copper ore, and the Federal Mining & Smelting Co. is preparing machinery to treat the zinc-lead-silver ore from the old Frisco mine, so the year closes with the greatest well-directed activity all over the district.

Mining litigation because of apex rights was confined to the Wardner or Yreka District, the pending case, Bunker Hill & Sullivan vs. Caledonia Mining Co., having just been dismissed, the former company granting concessions to the latter and receiving a portion of its stock, on a basis advantageous to both. Stewart Mining Co. vs. Ontario Mining Co. was tried before District Judge Woods during January. Many of the best known geologists and engineers appeared for either side. The plaintiff claimed apex rights based upon an edge of the vein against a fault

[1] Stanley A. Easton, *Eng. Min. Jour.*, Jan. 10, 1914.

of unknown but admitted great throw. Defendant asserted the edge was not an upper terminal edge containing a legal apex to the vein, but was a side, or even undercut, edge, and thus no apex. Judge Woods held for defendant and was sustained by the Supreme Court, an appeal has been taken to the Supreme Court of the United States.

The particularly satisfactory feature of the present state of the industry is the good low-level development in the old mines, notably in the Green Hill Cleveland on the famous Standard-Mammoth ore-shoot; the Hercules has a fine ore-body on its lowest level, as have also the Hecla and Bunker Hill & Sullivan.

No new promotion of magnitude was made during the year, nor was outside capital in any large amount brought to the district, the mining companies have done their own financing from their outset and the new enterprises have had their principal and almost entire support from local mine-made money. So then, the opening of a new year finds this sound industry looking to another period of legitimate activity and, with a fair metal market, confidently expecting and planning a betterment of the well-earned and substantial results of 1913.

Lead-silver ore development in Idaho[1] outside of the Cœur d'Alene district has received considerable attention and some important resources of ore have been developed and put into shape.

The most flattering result in this connection has been at the Wilbert mine in the Dome mining district, 40 miles north of the nearest railway shipping point at Arco, Blaine County, Idaho. This property developed an ore-shoot nearly 300 ft. long and 3 to 10 ft. wide that has been opened to a depth of 300 ft. and affords an average mill feed of from 25 to 30 per cent. lead. This ore is low in silver but the mill product averages about 50 per cent. lead and affords employment for 40 six-horse teams for hauling to the railroad, and has yielded 1000 tons per month of this class of mineral throughout the greater part of the year.

At the Gilmore district in Lemhi County, the ore shipments have aggregated about 22,000 tons of crude oxidized ores carrying a little better than 30 per cent. lead and 15 oz. silver per ton with 50 cents gold. Most of this ore was derived from the Pittsburg-Idaho and Latest Out mines, but shipments have been retarded on account of the necessity of some extensive permanent development plans and new equipment. Both the Pittsburg-Idaho and the adjoining mine, the Latest Out, show strong ore manifestations in deepest levels.

In Custer County, the Red Bird mine, owned by the Clayton Mining & Smelting Co., 60 miles from the nearest railway shipping point at Mackay, has been undergoing development throughout the summer,

[1] Robert N. Bell, *Eng. Min. Jour.*, Jan. 10, 1914.

under option to M. L. Ditto and associates and the result of this operation has disclosed a magnificent resource of relatively high-grade lead-silver smelting ore. The deposit has been developed to a depth of 900 ft. through a series of crosscut tunnels and shows 100,000 tons of lead carbonate ore carrying an excess of iron oxides that will average about 20 per cent. lead and 20 oz. silver. The property is being equipped with a smelting plant of 100 tons daily capacity and with motor-truck haulage can be handled at a handsome margin of profit in spite of its isolated position.

The Continental mine in Bonner County is Idaho's Farthest North mine, adjoining the International Boundary Line, and 24 miles from the nearest railroad shipping point. Its merits have been appreciated for the last 10 years but, owing to inaccessibility, it has been idle until the last year. This mine has one of the most flattering surface evidences of lead-silver ore deposit that has been discovered in Idaho. The enterprise has been financed through the assistance of the International Smelting Co. The deposit gives eminent evidence of deep-seated permanency and affording an important and profitable production of desirable smelting ore during the coming years.

In the same county, 7 miles east of Bonner's Ferry, the Idaho-Montana Amalgamated Co. has equipped its property with a 50-ton daily capacity concentrating mill which has recently been put in operation. This property carries an interesting deposit consisting of a pronounced quartz vein in a quartzite formation, the ore-body is localized to a wide zone of intrusive rock, resembling diabase and is several hundred feet long with two shallow surfaces openings 10 to 20 per cent. lead associated with an excess of coarse iron sulphides containing gold and silver.

At Clark's Fork in the same county, 1 1/2 miles north of the Northern Pacific main-line station of that name, the Lawrence Mining Co. equipped its property with a concentrating mill of 50 tons daily capacity which operated during a part of the year with a resulting product of several cars of very clean high-grade lead concentrates practically free from zinc and containing carload shipping values of 70 per cent. lead with 12 oz. of silver.

Another property in this same county, locally known as the Webber Mine, at Lakeview, has been opened through a long crosscut tunnel in the sulphide-ore horizon and is showing some shipping mineral carrying high values in silver and lead.

Missouri (By H. A. Wheeler).[1]—The southeastern, or disseminated lead district of Missouri, produced about 137,000 tons of pig lead in 1913, which had an approximate value of $11,700,000. This is about 10,000

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

tons, or 7 per cent. less than in 1912, due to a strike of the miners' union last summer that shut down the entire district for nearly a month. But for this occurrence, ths output would have exceeded that of the previous year, 146,913 tons. Even with this shrinkage the district maintains its position as the largest lead producer of the world, derived from a simple ore with no silver or other by-products to assist in lowering costs, as have the mines in the West, Spain, Germany, Mexico, Australia and the other large lead producers.

Strikes have been rare and hitherto only individual mines have been affected as, with one exception, they were not complicated with union affiliations. For the past 3 years the union has again been building up its membership and decided to test its strength last summer. It demanded recognition of the Western Federation and increase of about 20 per cent. in wages. When the operators refused to recognize the union and only conceded an advance of 5 per cent., it called a strike on Aug. 16 and refused to allow the running of the mine pumps. Although the mines are wet, their size permitted several conferences with the State Labor Commissioners before the pumps were submerged. When an advance of 25 cents daily or about 10 per cent. was conceded after 11 days, the strike was called off without the union recognition. About a month was lost before the mines were unwatered and normal conditions were restored. There was no trouble during the strike, nor were any strike breakers imported. The majority of the miners are local Americans and the foreigners, mostly trammers, are Hungarians.

The unsettled labor situation and the low price of lead discouraged prospecting, beyond the frilling necessary to extend and develop the present ore-bodies, and the partially developed Manhattan, Penicaut and Bogy lands remained inactive.

The adjoining counties of Washing, Jefferson and Franklin that have thus far only produced lead from the shallow diggings and small veins, were quiet during the last year and the shipments were small. This is due to the low price of lead, rather thad exhaustion of deposits.

The important question of the presence of disseminated lead deposits in Washington County, is receiving attention from a St. Louis Co. which began drilling last fall near Potosi. Only one hole has been finished, but the results are encouraging, as 3 ft. of disseminated ore is said to have been cut at 827 ft. depth, and 4 ft. at 930 ft. depth. While I have not examined the cores from this important hole, excellent authorities state that the ore is good grade. If this is correct, it is likely to lead to the rapid development of Washington County, where the shallow "diggings" are much richer than in St. Francois County, and which several experts predict will surpass St. Francois County, the present record-holder.

Thus far there have been only a few holes bottomed to the underlying sandstone, about 1000 ft., in Washington County, compared with several thousand holes in St. Francois, and of the latter but a small percentage have found pay ore.

That St. Francois County operators are so astoundingly slow in prospecting in Washington County is not surprising, as they are accustomed to 200- to 600-ft. drilling at a cost of 30 to 70 cents per ft. Hence, 1000 ft. of drilling at $1.50 to $2 a foot has frightened them off, especially as the lead market has not been strong since 1907. Washington County probably will be opened up by outsiders, who have been educated to the $2 to $5 rates that prevail in other camps and who have not been spoiled by the unusual conditions for cheap diamond drilling in St. Francois County.

The fiscal year of the St. Joseph Co. showed net earnings of $637,910 out of which $597,300 was distributed in dividends. This was on a lead market that averaged 4.3 cents, while in 1907, when the market averaged 5.7cents, the net earnings rose to $2,038,820.

Internal dissensions made 1913 a stormy year that demoralized the local *esprit du corps*. A St. Louis stockholder made a bitter attack on the administration, especially on the New York office, that was carried on through circulars in the press and finally in the courts. A stockholders' committee finally harmonized the conflicting interests, after making some changes in the directorate and introducing some reforms, and an efficiency engineer has been engaged to effect economies. The stock of these two companies is in the same hands and a consolidation is purposed under which they will be operated by a single administration.

The St. Joseph Co. has distributed about $9,000,000 in dividends on an original capital of $1,000,000 that was issued for land, while $30,000 for plant and working capital was realized by the sale of bonds. To-day there is $10,000,000 stock outstanding that represents stock dividends based on solid assets. A large share of the earnings has been reinvested, providing increased acreage, towns, mines, mills, smelting plant and an extensive railroad system.

The Doe Run Co., which is much younger, has distributed over $3,000,000 in dividends, and while more cash was put into the company most of the $6,578,500 stock outstanding to-day represents stock dividends based on reinvested earnings. There is $10,000,000 of unissued stock in the St. Joe treasury, about half of which will be used in absorbing the Doe Run Co. The smelting plant of the St. Joseph Co., at Herculaneum, on the Mississippi river, where the concentrates of the St. Joseph and Doe Run Cos. are treated, has been further improved. The large bag-house is about completed. A 7-hearth Wedge mechanical

roaster has been added for roasting matte, in addition to a 36-ft. Holthoff roaster. The ore is roasted by six Dwight-Lloyd sintering furnaces, and the Savalsberg pot-roasting plant has been dismantled. The 350×20 ft. stack is effectively diffusing the smoke and no complaints are heard from the farmers. This smelter produces about 14 per cent. of the pig-lead output of the United States.

The Desloge Lead Co. had an active year and suffered only slight loss in its output through the shut-down caused by the strike. Since then it has not operated the No. 4 shaft on Big river, and is concentrating the work at the old No. 3 shaft at the mill and the new No. 6 shaft that is close to the Washington County line.

The St. Louis Smelting & Refining Co., under which the National Lead Co. operates its mining department expanded its operations in 1913 by taking over the extensive Mine La Motte property under a 10 per cent. lease, with the privilege of purchase at $800,000. The property is in Madison County and has been worked for over 150 years in the shallow "diggings," and for the past 40 years in the deeper disseminated deposits. There are several disseminated ore-bodies that occur along a well-defined fault and in marked contrast to the ideas promulgated in the recent report of the Missouri Geological Survey dealing with the disseminated lead belt. While this report has added much valuable information and contributed a fine set of maps and sections of this district, it has also presented theoretical ideas and the results of incomplete studies that are proving decidedly harmful in discouraging prospecting in some very promising areas.

The Federal Lead Co., one of the operating departments of the Guggenheim Exploration Co., had a very active year and continued operating under lease the former Catherine property at Fredericktown, Madison County, in addition to its large holdings and 4000-ton mill at Flat River. The No. 7 and No. 11 mines, on the former Central property, were connected last year, and No. 11 shaft remodeled to take care of the output from both mines. Balanced 5-ton skips, operated by a double-drum electric hoist, were installed.

This property is on Big River, between the Gumbo and Hunt mines of the St. Joseph Co., and has 357 acres. A shaft, 430 ft. deep, was sunk to the ore-body in 1912 after it had been repeatedly condemned by most of the local operators during the past 15 years. A spur from the Hoffman Branch of the M. R. & B. T. R. R. was built in 1913, to it, since which active shipments have been made to the National Lead Co., under a contract by which they both mill and smelt the ore. The shipments assay from 9 to 11 per cent. lead, which is exceptionally rich, as the average assay of ores of the district usually ranges from 4 to 6 per cent.

In the Joplin region, as estimated from the weekly ore sales reported in the local papers, there was a decrease in the production of blende concentrates and gains in the output of silicate and lead concentrates. The output of lead concentrates is estimated at 48,000 tons. The lead contained in the lead concentrates aggregated 38,159 tons, again of 2,244 tons over 1912. The principal developments of the year were the extension of mining operations in the territory north and west of Joplin in Missouri, about Lawton and Badger, Kans., and north of Miami, Okla. At the latter place the runs of ore worked in previous years have had a northwesterly bearing, but there has recently been developed a northeasterly zone of ore-bearing ground reaching from the older mines to and beyond the Kansas State line. Practically all the territory along this zone is owned or under option or lease by mining companies and an extensive campaign of drilling is being carried on.

The Missouri production of metal for the year amounted to 152,430 tons, a decrease of about 10,000 tons. This leaves Missouri in the lead in metal production, but Idaho takes first place in the mine production.

Montana.—The 1913 production of lead showed small increase, amounting to 3214 tons against 2500 tons in 1912. The increase was largely due to shipments of lead concentrates and residues from zinc concentrates from the Butte and Superior Mine at Butte. There was much activity south of Libby in Lincoln County but principally in development work. At the King and Queen property in Sanders County, galena was shipped and a 75-ton concentrating plant was constructed.

Nevada.—The smelter production from Nevada amounted to 6142 tons, a slight increase over the preceding year. The mine production of the state, however, was somewhat below the figures for the preceding year, the decrease being largely due to decreased shipments from the Bullionville Tailing Dump near Peoche. The Eureka County mines increased their output and the Yellow Pine district maintained its previous output.

South Dakota.[1]—At Carbonate camp, which 25 years ago was the scene of successful mining of high-grade silver-bearing lead carbonates, the Titanic Co. has started a shaft to the 300-ft. point, to explore an untouched section which old timers declare contains ore. A good plant of machinery has been installed, and all preliminary work advanced, so that mining will proceed more briskly in the near future.

Utah.—The metal production for Utah for the year 1913 amounted to 71,069 tons, against 60,664 tons in 1912. The mining production for the year shows a total of about 83,000 tons. Of this production over

[1] Jesse Simmons, *Eng. Min. Jour.*, Jan. 10, 1914.

40 per cent. was obtained from the Bingham district, 25 per cent. from the Park City district and 16 per cent. from the Tintic district.

The Silver King Coalition,[1] Daly-Judge, and Daly-West, of Park City, producing silver-lead ores, the Utah Apex, Bingham-New Haven, United States properties and Utah consolidated at Bingham producing lead-silver ores, were the principal silver and lead producers in 1913. The Centennial-Eureka, Iron Blossom, and Gemini in Tintic added to the output from siliceous copper-gold-silver ores, from siliceous silver ores, and from silver-lead ores, respectively. The Chief Consolidated produced siliceous silver-gold-lead ore. The Mines Operating Co. leasing on the Ontario at Park City, treated low-grade ore and stope fillings in its new mill handling up to 150 tons a day. The process consists of a chloridizing roasting with a large excess of salt, and with powdered coal, leaching with water, and precipitating on copper and scrap iron. The American Flag and Silver King Consolidated opened new ore-bodies, and the Thompson-Quincy was an added shipper to the camp.

The Knight mill at Silver City was built to treat low-grade Tintic ores by the Christensen leaching process, consisting of a salt roast of the ore (with pyrite), and leaching with the acid liquors resulting from the condensation of the roaster fume, fullowed by precipitation on copper and scrap iron. Experimental work was carried on at this plant during the latter part of the year.

Lead Mining in Foreign Countries

Canada.[2]—The total smelter production of lead in 1913 was 39,468,729 lb., but this includes lead from American ores and lead contained in scrap, etc., resmelted, the recovery from Canadian ores being 37,662,703 lb. valued at $1,754,705, an average of 4.659 cents per pound, the average wholesale or producer's price of pig lead in Montreal for the year.

In 1912 the production was 35,763,476 lb. valued at $1,597,554.

The shipments were practically all from British Columbia mines in 1913, though a small production is reported from Ontario and the Yukon.

The mines of British Columbia were very active during the year and the total lead contents in ores shipped is estimated as slightly in excess of 54,000,000 lb. Allowing for "lag" and the losses due to smelting the increased difference between ore contents and smelter recovery would indicate that a considerable amount of lead ore was in stock at the close of the year.

The exports of lead ore, etc., are given as 329,960 lb. valued at $9136.

[1] E. R. Zalinski, *Eng. Min. Jour.*, Jan. 10, 1914.
[2] From Preliminary Report on the Mineral Production of Canada, 1913.

The total value of the imports of lead and lead products in 1913 was $1,215,434 including old scrap and pig 11,199,500 lb. valued at $464,117, manufactured lead 9,865,980 lb. valued at $320,797, manufactures N.O.P. $155,179, and litharge and lead pigments $275,341.

The average monthly price of lead in Montreal during 1913 was 4.659 cents. This is the producer's price for lead in car lots as per quotations kindly furnished by Messrs. Thos. Robertson and Co.

The amount of bounty paid during the 12 months ending December 31, 1913, on account of lead production was $57,956.70 as compared with $118,425.74 in 1912.

China (By T. T. Read).—Fair quantities of lead are produced in China, Kweichou, Ssuchuan and Yunnan provinces yielding the larger part of the total, and considerable quantities of lead are exported from Hunan province to Belgium, the export figures being as follows: 5094 tons in 1910; 5325 tons in 1911; and 4207 tons in 1912. Very little lead is exported, all the bullion produced in the country being absorbed by domestic consumption and 5000 to 8000 tons of sheet and pig lead being exported. There is one smelting works of modern construction at Wuchang, built by a Mr. Laidrichs, and now operated chiefly for the wet concentration of lead and zinc ores by Carlowitz & Co. Lead ores occur in many parts of China, but so far have not been made the basis of much of an industry for a variety of reasons.

There has been a notable increase in the imports of lead in various forms into China during the past year or so and the increase is continuing into the present season. The trade has shown considerable fluctuations during the past 5 years. The metal is used in various industries, largely for the manufacture of sheet lead for lining tea chests, the manufacture of pewter ware, and for purposes usual in other countries. In 1913 the total imports amounted to 7502 short tons of pigs and bars valued at $562,176 and of 246 short tons of sheet lead valued at $22,574, as compared with 6610 short tons of pig and bars valued at $465,521 and of 190 tons of sheet lead valued at $16,500 in 1912. Importations in earlier years were considerably larger, the importations of both classes in 1910 running as high as 12,590 tons valued at $648,738.[1]

Russia.[2]—Russia's large importations of various metals shows her complete dependence on the foreigner for some of them. The question of Russia's lead supply is now much discussed, and the following table shows Russia's production and consumption of lead in 3 years, 1909 to 1911 inclusive, in tons:

	Imported.	Produced.	Consumed.
1909	40,000	800	40,800
1910	50,000	1,290	51,290
1911	41,200	1,720	42,920

[1] Consul General Geo. E. Anderson, *Daily Consular and Trade Reports*, June 16, 1914.
[2] E. de Hautpick, *Min. Jour.*, 94, 440 (1913).

Thus Russia produces about 2 per cent. of the lead she consumes. Lead reserves are known in many parts of Russia, but the production referred to takes place in the Caucasus and Trans-Baikal, the Kirghis Steppes, Altai and the Urals.

In the Caucasus, lead is at present smelted only in the Algahir Works in the Ter province from ore obtained at Sadonsky mines, lying about 20 miles from the works, where the lode is rich, declining 75 deg., and stretching at first N.W. But with a series of dislocations the lode gradually inclines eastward. The width increases at depth to 84 ft. The ore-body is quartz; it contains lead glance (PbS), zinc blende, pyrite, etc. Generally the ore contains 6.7 per cent. lead, 0.02 per cent. silver, 0.06 per cent. copper, 0.013 per cent. zinc. The annual production of lead at the Alaghir works is about 1400 tons.

In the Trans-Baikal territory the lead ores are particularly rich in the Nertchinsk district, especially so in the East, where there are about 90 mines, of which only five are being exploited—all in limestone or in close proximity to it. The ore is lead glance. But for want of usual industrial facilities, roads, etc., this industry is relatively poorly developed.

The lead mines of the Kirghis Steppes (Akmolinsk and Semipalatinsk) are of ancient date. Out of 500 mines only a few are worked and on a small scale. The best known are in the Karkaralinsk district, where the ore contains 40 to 78 per cent. of lead, 1.21 per cent. copper, 0.225 per cent. silver. The rich lead mines of Berkara are north of this. But all suffer for want of enterprise and capital, with the aid of which a fine lead industry could be built up there.

The Atlai lead mines are divided between the Smaeinogorsk (south) and the Salairskv (northeastern) groups. The ore yields 300 to 650 lb. of lead and 2 oz. to 4 lb. of silver to the ton. The former lie about 150 miles from Barnaul.

In the Urals a lead producing industry has been introduced recently, in the North Ekaterinburg district, with ore from the Blagodat mines. But hitherto Urals lead mines have not been promising, and as lead mines will probably not be worth much, but where the ore includes silver and even gold, it merits attention.

Diligent search for lead has taken place in the Primorsk province (Pacific Coast), where a large concentrating plant is in course of erection near the mines in the valley of the river Uan-Tchan on Olga Bay, where the ore contains 22.19 per cent. of lead and 18.90 per cent. of zinc. Hitherto exported crude to Germany, the concentrated ore will now be shipped to Russian ports in the Baltic and Azoff Seas, where smelting works will be constructed. The 1912 production of ore was 30,000 tons.

Besides the foregoing, many untouched lead deposits are known in the

country, particularly the Kuban Chudeksky group, near the sources of the Kuban river, where lead lodes extend 20 miles (lead glance and zinc blende). The width of the ore-bearing zone is 4 miles. The lodes are rich and regular. Then the Sucham deposits lie almost on the Black Sea. While in the Caucasus lead is only produced from the Sadon mine, there are many Caucasian lead ore deposits. The customs duty on lead is 92s. 3 1/2d. per ton. It is too low. A 30 per cent. duty, as on copper, would establish a lead industry.

Spain.[1]—The study of the lead mines in Spain is of the greatest interest for those who study the development of mining questions. Spain occupies the second place in the lead production of the world. The United States alone shows a total superior to that of the Spanish mines. Even so, the difference is not so very great. In Europe, of course, Spain easily holds the first place, greatly outdoing Germany with her extensive lead-mining industry.

There is another reason why a study of all the Spanish lead fields is important at the present time, and that is because her lead production will in a short time hence increase probably threefold. During the year 1911—that is to say, when the price of lead varied from £15 to £17—the total Spanish production was over 400,000 tons. It must be remembered that when the price of lead falls below a certain price a third of the mines stop working. Only the mines belonging to the wealthy companies can continue working in times of low prices. A clear proof of this was afforded last year. When political troubles in Mexico rendered the working of those mines impossible, and the rates of the lead began gradually to rise, the mining offices of the lead provinces began to note a great request for mining concessions, and a short time after this movement was verified by a rapid increase in the exports. These variations in production are due partly to the difficulty of communications and the scarcity of railways, but it is not less certain that they are caused by the want of business energy. Concerns are started in the hope of obtaining great profits in a short time. They snatch out the ore which is in sight without developing ground for future working, and when the necessity comes to meet fresh expenses the companies are dissolved and the mines are forsaken.

The Fields.—Although there is lead in many places, the lead fields in Spain are concentrated in three regions. Two are in the center and the south, and the third near the eastern shore. Those of the center and of the south comprise the provinces of Córdoba, Ciudad Real and Jaén.

The first or central region (Córdoba and Ciudad Real) is the most interesting for those who are attracted by the industry, because it is

[1] From *Min. Jour.*, 94, 707 (1913).

easier to improve and there is more ample ground for individual undertakings. These two fields make two extensive zones, which lie between the plain of the River Guadiana and Sierra Morena. The veins of argentiferous galena are found in the quartz rocks and the Silurian slates. In all these veins we observe a constant direction from southwest to northeast. The ore occurs spread in alternate columns of rich and barren ground. The galena is generally accompanied by blende, but always in small quantities. Very often these veins are rich in silver, varying in tenor between 400 grm. and 3000 grm. per ton.

One very significant fact, which proves at the same time the great wealth of the field and the poverty of the means of the exploitation, may be noted here. In the province of Ciudad Real there are 700 lead mines comprising an area of 12;000 hectares, that paid the tax called *canon superficial* of 15 pesetas for every hectare (10,000 square meters). The fact that proprietors keep these mines notwithstanding the cost, proves that they have a practical value, but out of the 700 mines, only 20 are at work. The richest group in this region is that of San Quintin, which belongs to the Company Minera y Mettalúrgica de Peñarroya, owners of the chief smelting works of Spain, and of the coal mines of Peñarroya and Puertollano.

The mines of the province of Córdoba are similar to those of Ciudad Real, since all the veins belong to the same general rock system. The richness of the ores of this province is very considerable. The lead shows itself in quantities varying between 60 and 80 per cent. The silver is found also in these veins in very large quantity, there being several mines in which the galena contains silver at as high as 36 kg. per ton of ore, giving a value of 3600 pesetas. The most productive mine in this province belongs also to the French Peñarroya Co., and during the current year it has yielded 30,000 tons of lead ore. The total production of the Córdoba and Ciudad Real region in 1912 was 70,000 tons, worth 20,000,000 pesetas.

Adjacent to these centers and scattered in Andalusia and Estremadura there are also great lead mines. The province of Badajoz from its mines of Azuaga extracted in 1912, 40,000 tons of lead ore. Granada in the same year produced 16,000 tons. The exploitation of Sierra Almagrera (Almeria) has given 70,000 tons, and it is necessary to consider that in this region the greater part of the mines was flooded, and notwithstanding subsequent efforts it has not been possible to pump them dry. The geology of the field in this region is such that the underground water circulates through all the mines, and consequently all the mines must be pumped as one.

The Smelters.—The Peñarroya smelter belonging to a powerful

French company receives the ores from all these mines and sends the lead bars to the port of Seville, whence they are shipped to the markets of Europe. In order to give an idea of the size and importance of the smelter, it may be said that during last year it produced lead to a value of 35,000,000 pesetas, while the silver extracted from the lead ore reached a value of 8,000,000 pesetas. This smelter being very far from the mining center of Ciudad Real, it is strange that no company has tried to establish a smelter in this field, seeing that many of the mines could then be worked, thanks to the lower cost of transport. It is doubly strange that no company has undertaken this business, taking into account that nearness of the lead mines to collieries, which could provide cheap and abundant fuel.

Ore Prices in the Spanish Markets.—The ruling lead market in Spain is that of Cartagena. The unit for the purchases of the ores is the *Quintal castellano* (46 kg.) for lead, and for silver is the *Onza castellana* (29 grm.). For the silver contained in a lead ore to be paid for it must contain at least 250 grm. per ton, because that is the smallest quantity requisite to pay the separation (*desplatacion*) of the silver from the lead. During 1912 the average price of lead was 20 pesetas per 46 kg.; the silver price was 3 pesetas per onza. This year prices have gone down a little for lead, reaching now only from 16 to 18 pesetas per 46 kg., the silver continuing steady.

Bibliography

Handy, R. S.—Milling *vs.* Hand Sorting of Lead Ores. *Min. Sci. Pr.*, Mar. 15, 1913.

Heriot, E. Mackay.—The 'El Hoyo' Lead-mining District, Spain. *Min. Jour.*, Mar. 8, 1913, p. 229.

Hershey, Oscar H.—Origin of Lead, Zinc and Silver in the Coeur d'Alene, Idaho. *Min. Sci. Pr.*, Sept. 27, and Oct. 4, 1913, pp. 489 and 529.

Keyes, Chas. R.—History of Lead Mining in Upper Mississippi Valley. *Min. Eng. World*, Feb. 8, 1913, p. 303.

Klockmann, F.—Die Blei und Zinklagerstatten Aachens. *Metall u. Erz*, Aug. 30, 1913, p. 686.

Larsh, Paul A.—Lucky Bill Lead-vanadium Mine. *Eng. Min. Jour.*, Dec. 13, 1913, p. 1103.

Leroy, O. E.—Silver, Lead and Zinc Deposits of Slocan, B. C. *Can. Min. Jour.*, Sept. 15, 1913, p. 580.

Lindstädt, Bergassessor.—Die Blei und Zinkerzlogerstätten der Provinz Guipuzcoa in Spanien mit besonderer Berücksichtigung der grube Catavera II bei Onate. *Metall u. Erz*, Aug. 8, 1913, p. 647.

Nichols, Ralph.—The Lead-silver Mines of Gilmore, Lemhi County, Idaho. *Min. Eng. World*, Dec. 27, 1913, p. 1158.

Tait, P. G.—The Magnet Silver-lead Mine, Tasmania. *Min. Sci. Pr.*, July 19, 1913, p. 102.

Recent Improvement in Lead Smelting

By H. O. Hofman

Introductory; Physical Properties; Alloys; Compounds

Grain of Lead and of Lead-Alloys.—In a study of the influence of annealing upon the growth of grain in some forged metals and non-ferrous alloys, Robin (*Rev. Métallurgie*, 1913, X, 722, 758) finds in regard to lead that annealing begins to show a decided effect at 70° C., which increases up to 80° C., and becomes very apparent at a temperature-range extending from 250–280° C., to the melting point. With lead alloys he finds that Sn, Zn, Sb, Hg, Bi and Mg interfere with the growth of grain, in the order given, Sn being the most powerful.

Recrystallization of Lead.—The recrystallization of cold-worked lead at ordinary temperature, which takes place very slowly, may be accelerated by the use of a dilute acid (*Baucke, Internat. Zeits. Metallog.*, 1912, II, 243; *Jour. Inst. Met.*, 1912, VIII, 339). The greatest diameter of grain obtained in the experiments was 70 mm.; the growth of crystals was more readily noticed with lead pipe than with sheet lead. Cold-worked lead is more readily attacked by corrosion than cast lead.

Disease of Lead.—Disintegration of objects of art made of lead was observed at the Cluny Museum, Paris (*Compt. rend.*, 1912, CLIV, 154, 1600; *Brass World*, 1913, IX, 256; *Eng. Min. Jour.*, 1913, XCVI, 454). Matignon found upon analysis that $PbCl_2$ was present; he also induced the disease by rubbing lead objects with $PbCl_2$.

Corrosion of Lead.—A paper by R. H. Gaines (*Jour. Ind. Eng. Chem.*, 1913, V, page 766; *Eng. Record*, 1913, LCVII, 685) deals with the resistance to chemical corrosion of lead pipe by the drippings of concrete and soil, by water, and by electrolysis.

Secondary Lead.—The treatment of secondary lead materials, (Junk Lead, Min. Ind., 1912, XXI, 544) as distinguished from primary ores, is receiving some attention. Thus the report of the U. S. Geol. Survey, by C. E. Siebenthal, upon the Production of Lead in the U. S. in 1912, notices, in its enumeration of the 33 active and 15 inactive lead plants of the country, the existence of four works confined to the working of secondary lead materials. Most Eastern lead works treat with their primary, some secondary lead; further manufacturing plants, as *e.g.*, the Westinghouse Electric and Manufacturing Co. (*Foundry*, 1913, XLI, 129), have important divisions for working their secondaries among which lead and lead-alloys are well represented.

Lead-Copper.—The investigation of Waehlert (*Metall und Erz*, 1913, X, 578) shows that if between 19 and 24 per cent. Cu of the horizontal

branch of the Pb-Cu curve representing the conjugate solutions of Cu in Pb and of Pb in Cu at 953° C., the temperature is raised to 1025° C., there is formed a homogeneous solution.

Lead-Bismuth.—The specific heats and electric and thermal conductivities of lead-bismuth and bismuth-tin alloys have been investigated by O. Richter (*Ann. Physik*, 1912, XXXIX, 1590; *Jour. Inst. Met.*, 1913, IX, 232). He finds that the values for specific heats are greater than those obtained by calculation, that those for electric and thermal conductivities are smaller, and that the ratio of electric and thermal conductivity remains constant throughout.

Lead-Tin.—A study by Munger (*Metal Industry*, 1912, X, 290) upon the thermal changes in lead-tin alloys shows that the alloy with 33.3 per cent. Sn remains plastic for the largest period of time, and one with 78 per cent. for the shortest.

Lead, Tin, Copper.—According to Carnevali (*Chem. Zeitung*, 1911, XXXV, 509; Bull. No. 21, *Am. Inst. Metals*, April, 1913, 37) lead always remains in the free state in this series of ternary alloys and as eutectic modifies the plasticity.

Porous Lead-Antimony Plates.—The eutectic of the lead-antimony series of alloys contains Pb 87 and Sb 13 per cent., and freezes at 228° C. By heating a lead plate which contains Pb 96 per cent. to the melting point of the eutectic and separating the eutectic by means of a centrifugal machine, Hannover (*Rev. Mét.*, 1912, IX, 641; *Brass World*, 1913, IX, 323) obtains a porous plate well suited for storage batteries.

Lead, Silver, Tin.—Parravano, (*Internat. Zeits. Metallog.*, 1913, III, 15; *Jour. Inst. Met.*, 1912, VIII, 322) has furnished a supplement of a theoretical nature of his earlier studies on this series of alloys. (MIN. IND., 1911, XX, 470.)

Lead, Bismuth, Tin, Cadmium.—This series of quaternary alloys has been studied by Parravano and Sirovich (*Gaz. chim. ital.*, 1912, XLIII, I, 630; through *Jour. Inst. Met.*, 1912, VIII, 322). It appears that no chemical compounds are formed, and that any solid solutions are resolved into their components before the quaternary eutectic point is reached. The most fusible alloy contains Pb 27.27, Bi 49.50, Sn 13.13 and Cd 10.10 per cent.

White Metal Bearing Alloys.—Schäfer (*Metall u. Erz*, 1913, X, 470) discusses in a general way the properties a bearing metal ought to fulfil and gives in the accompanying table I the chemical analyses and mechanical properties of some important industrial alloys.

Of these Nos. I, II, III and VII meet the required conditions; Nos. IV and V do not; No. VI may be used when cheapness is the essential factor; the addition of Ni is to prevent the segregation of lead.

TABLE I.

	White Metal Bearing Alloys.						
	I.	II.	III.	IV.	V.	VI.	VII.
Zn	19.00	81.92	49.96	4.5	79.0	14.19	1.65
Sb	15.34	8.43	14.59	10.5	6.5	15.29	.....
Pb	63.55	1.11	32.31	85.0	10.5	68.61	.....
Cu	1.57	8.44	3.21	.....	4.0	.....	5.82
Sn	0.37	.....	.....	.....	.....	.....	.....
Ni	.....	.....	.....	.....	.....	1.52	.....
Al	.....	.....	.....	.....	.....	.....	91.68
Fe	.....	.....	.....	.....	.....	.....	0.90
Si	.....	.....	.....	.....	.....	.....	0.36
Specific gravity	9.31	7.49	8.15	.....	.....	9.52	2.98
Yield point, lb. per sq. ft.	963,500.0	1,025,000.0	881,500.00	73,800.0	307,500	553,500.0	1,025,000.0
Compression strength at yield point, lb. per sq. ft.	23,985.0	2,644.5	22.55	1,127.5	1,845	2,460.0	2,562.5
Elastic limit, lb. per sq. ft.	1,537.5	2,111.5	1,640.00	758.5	1,435	1,865.5	2,562.5
Brinell hardness number	25	34.7	25.2	15.0	30	31.5	72

Babbit-Metals.—The progress made by the committee of the American Society of Testing Materials, with G. H. Clamer as chairman, is recorded in *Brass World*, 1913, IX, 126. The subjects studied are sampling, chemical analysis, compression and hardness tests.

Lead Oxide-Ferric Oxide.—In the investigation of this series, Kohlmeyer (*Metall u. Erz*, 1913, X, 447, 483) started with a study of the behavior of Fe_2O_3 upon heating. He found that the red oxide turned black at 920–950° C.; fritted at 1370°, lost oxygen and formed the first chemical compound $1FeO.3Fe_2O_3$; that it fused at 1470° and formed $3FeO.5Fe_2O_3$, that the loss in oxygen increased up to 1520° when there was formed $3FeO.4Fe_2O_3$; and that at 1600° the fourth and last compound $1FeO.1Fe_2O_3$ was formed which corresponds to the magnetic oxide Fe_3O_4. A ferro-ferrite heated to 500° C. with access to air was found to take up oxygen.

In the study of the system $PbO\text{-}Fe_2O_3$, the author determined five chemical compounds $3PbO.1Fe_2O_3$; $3PbO.2Fe_2O_3$; $3PbO.3Fe_2O_3$; $2PbO.3Fe_2O_3$; and $1PbO.2Fe_2O_3$, all of which are decomposed upon fusion and form ternary mixtures of $PbO\text{-}FeO\text{-}Fe_2O_3$. Their constitutions can not be accurately determined on account of the unavoidable decompositions caused by the volatilization of PbO; it is believed, however, that there exists the compound $1PbO.1FeO.4Fe_2O_3$. The melting point of PbO, 885° C., is depressed to 752° C. by the addition of 12 per cent. by weight of Fe_2O_3.

Lead Sulphate-Ferric Oxide.—The investigation of Proske (*Metall u. Erz*, 1913, X, 415; *Eng. Min. Jour.*, 1913, XCVI, 207) upon the decom-

posing effect of Fe_2O_3 upon $PbSO_4$ showed that Fe_2O_3 assisted the decomposition of $PbSO_4$ at temperatures at and above 900° C., also that the action of Fe_2O_3 was less energetic than that of SiO_2, and that at 1100° C. the entire SO_3 was driven off. It was also found that Fe_2O_3 heated to 1200° C. was a more powerful decomposing agent than the ordinary red oxide. If FeO in contact with $PbSO_4$ was heated in a current of air it was oxidized up to 800° C. by the oxygen of the air, while above 800° C. it robbed the sulphate of part of its oxygen.

Lead Sulphide-Lead Chloride.—W. Truthe (*Zt. anorg. Chem.*, 1912, LXXVI, 161; *Rev. Mét. Extr.*, 1913, X, 370) in a study of various chlorides, proved in the system PbS-$PbCl_2$ the existence of an eutectic with PbS 22 per cent., freezing at 441° C.

Lithophone.—In the reduction of $BaSO_4$ to BaS for the formation of this white paint with $ZnSO_4$, it has been found (F. Webb, *Min. Eng. World*, 1913, XXXVIII, 727) that the addition of NaCl to the charge reduces the reaction temperature of C upon $BaSO_4$ and the time necessary. On a commercial scale a reduction of 80 per cent. is readily obtained. $SrSO_4$ is reduced as readily as $BaSO_4$, but not $CaSO_4$.

Lead Ores

Lead Vanadium Ores.—A brief description of the Lucky Bill lead-vanadium mine near Bayard, Grant County, N. M. by P. A. Larsh (*Eng. Min. Jour.*, 1913, XCVI, 1103) shows among other matters that shipments made contained 9.16 per cent. V_2O_5, and that an average of all shipments assayed 27.72 per cent. Pb.

Purchasing of Ores.—Caetani (*Min. Sc. Press*, 1913, CVI, 684–724) analyses the contracts made between the ore-producer and the ore-smelter; he first considers the leading points of view held by the interested parties and then takes up in order, discounts and deductions, payments for metal contents, calculations of treatment charges, and gives characteristic examples. The paper might well appear in pamphlet form, as it ought to be studied with care by all interested in this subject.

Smelting Practice

Historical.—In their translation of Agricola's treatise "De Re Metallica," H. C. and L. H. Hoover have added introductions to the various chapters and comments to the text. In the "Historical Note on Lead and Silver" (reprinted in *Eng. Min. Jour.*, 1913, XCVI, 169) they note the existence in the British Museum of a figure of lead found in Egypt which antedates 3800 B. C. This is the earliest record; the earliest mention of lead is given as 1500 B. C. After 1300 or 1200 B. C. evidences

of lead became more frequent. The lead mines of Laurium, Greece, worked extensively about 500 B. C., have been reopened in recent years. (MIN. IND., 1905, XIV, 391, 1909, XXVIII, 482.) They furnish some ore which goes with the material collected from the ancient tailing- and slag-dumps to smelteries in Greece and in the south of France. Collins (*Eng. Min. Jour.*, 1913, XCVI, 457) commenting on the statements of the authors, believes that the ancients worked mainly carbonate and not sulphide lead ore The authors have come to the conclusion that in prehistoric times there existed the knowledge of the reduction of silver-lead ores, and of silver ores with lead ores, and in both cases that of the subsequent separation of precious metal from the lead bullion.

C. R. Keyes (*Min. Eng. World*, 1913, XXXVIII, 303) publishes some notes on the history of lead mining in the Upper Mississippi Valley.

New Publications.—E. Prost, professor at Liége, Belgium, has published a treatise on non-ferrous metallurgy entitled "Cours de Métallurgie des Métaux autres que le Fer," Béranger, Paris-Liége, 1912. Of the 888 pages of the book, 155 cover the subject of the smelting and refining of lead, and of the desilverization of lead bullion.

Lead Plant, International Smelting and Refining Co., Tooele, Utah.—(Thomson-Sicka, *Bull. A. I. M. E.*, Aug., 1913, 1209; Austin, *Min. Sc. Press*, 1913, CVI, 136.) Some of the principal features of this new lead smeltery have already been noted (MIN. IND., 1911, XX, 474, 554). These two papers give details. The ores are dropped or shoveled from railroad cars into receiving bins; from these they pass through the crushing and sampling mills onto a belt-conveyor which delivers by a tripper to suspended charge-bins. Fluxes and coke go direct to the charge-bins. The charge-bins are arranged in two adjacent rows of 26 in a building 260 by 32 ft. A bin is 10 ft. long by 16 ft. wide and 24 ft. deep; it has a sloping bottom provided with a chute and gate, and delivers into a weighing-hopper equipped with Fairbanks scales. Beneath the hoppers runs a track carrying motor-driven charging-cars. The blast-furnace charge-cars (Illustrated, *Eng. Min. Jour.*, 1913, XCV, 617), 14 ft. long and 5 ft. wide, holding 5–8 tons material, receive weighed amounts of ore, flux and fuel, and go to the feed-floor of the blast-furnace division where the hinged shutters closing the top of furnace are raised, and the bottom door of the car is opened allowing the charge to drop for a height of about 12 ft. The sinter furnace charge cars, 12 ft. long and 4 ft. wide, holding 3–5 tons material, go to the sintering division.

This building, 55 by 160 ft., contains ten standard 100-ton Dwight-Lloyd straight-line sintering machines, 42 by 264 in. The charges are ignited by oil-burners; the gases pass through a balloon-flue 440 ft. long, provided with dust-discharging gates, before they enter the chimney.

The sinter passes over grates into railroad cars. During one month 10,198 tons of mixture to be treated averaged Pb 19.3, SiO_2 19.4, Fe+Mn 20.6, S 15, CaO 3.7; the smelting sinter Pb 21.1, SiO_2 22.8, Fe+Mn 25.8, S 4.7, CaO 4.5 per cent.

The blast-furnace building, 16 by 138 ft., contains four furnaces with a fifth under construction. Two furnaces are 45 by 180 in. at tuyères; and two 60 by 180 in.; they are placed 30 ft. center to center. A furnace has three soft-steel jackets, 6 ft. high, on a side, each with four 4-in. tuyères tapering 0.5 in., and one end-jacket. Two furnaces have brick shafts extending from the jackets to the feed-floor and two an upper tier of jackets, 9 ft. high, surmounted by a short brick shaft. The height from center of tuyères to feed-floor is 24 ft. 8 in., the height of charge from 10 to 12 ft. The crucible is 32 in. deep; the forehearth 10 by 5 ft. and 5 ft. deep. The gases of a furnace are withdrawn beneath the feed-floor through a down-take ending in a cylindrical steel dust chamber 20 ft. in diameter and 18 ft. high, from which a branch uptake 6 ft. in diameter leads into the main flue, 8 ft. wide by 12 ft. high and 500 ft. long, provided with V-shaped bottom and doors for the removal of dust. The main ends at the fan-intake of the bag-house. The lead is removed from the siphon-tap into conical pots of 3 cu. ft. capacity and hauled to the drossing plant. Slag and matte are tapped either into the forehearth or into 7-ton pots to be transferred to a settling reverberatory furnace; this has a hearth 12 by 36 ft., holding 125 tons slag-matte, built into a steel pan, and a grate area of 64 sq. ft. There are two pouring-openings in the roof and a skimming-door at the front from which the slag is removed into a 22-ton car (Illustrated, *Eng. Min. Jour.*, 1913, XCV, 617) to be hauled to the dump. The matte is tapped from the side into 8-ton cast-steel ladles, mounted on transfer cars, trammed to the converter building of the copper department and blown for blister copper. The drossing plant, housed in a building 40 by 80 ft., contains four cast-iron kettles each holding 33 tons lead. The temperature of the lead bullion is watched by means of a pyrometer, the dross is freed from excess-lead by means of a Howard press, the clean bullion is siphoned into 100-lb. bars.

The bag-house has 10 bays, each with 144 bags, 18 in. in diameter and 30 ft. long. The shaking of bags is accomplished by the "reverse-current bag-shaking system" (drawing in paper of Thomson-Sicka, see also Hofman, "General Metallurgy," 1913, p. 856) in which the gas-main is shut off from a division of the bag-house, and connection made between the division and an exhaust flue which causes the bags to collapse; repeating the two operations from three to four times effectively shakes the bags in the most simple manner.

A blast-furnace charge weighs about 5000 lb., contains about 70 per cent. of sintered material, 16.7 per cent. Pb, and 7 per cent. matte; it is run with 12.5–14 per cent. coke, or including waste-slag with 12–13.5 per cent. A furnace puts through in 24 hours about 250 tons charge. The slag is calculated to contain SiO_2 31, Fe(Mn)O 35, CaO 17.5 per cent. A typical analysis of a rejected slag shell is SiO_2 32.5, FeO 29, MnO 6.0, CaO 15, ZnO 9.0, Al_2O_3 4.0, S 2.0, Pb 1.2 (wet). The matte assays Pb 15.8, Cu 7.8, Fe 45.0, Zn 6.0, undetermined 26.2.

Smelting at Alton, Illinois.—(H. B. Pulsifer, *Min. Eng. World*, 1913, XXXIX, 375.) At the works of the Federal Lead Co. non-argentiferous lead concentrates and slimes are smelted in the ore-hearth and the blast-furnace; the crude lead is liquated, poled, cast into bars, and sold as chemical lead; concentrates averaging Pb 70, CaO+MgO 4, SiO_2 2, Cu 0.15, S 13, Zn 2.5 and FeO 5 per cent. are treated in the ore-hearth in which about 50 per cent. of the lead content is recovered as metal, while the rest, in the form of gray slag and blue powder from the bag-house, is smelted in the blast-furnace.

In an oblong building 460 ft. long, there are in operation 30 ore-hearths placed in a row and 16 ft. apart. An ore-hearth is 4 ft. long, has a lead basin 10 in. deep, 13.5 in. wide at the bottom and 18 7/8 at the top, and a sloping cast-iron apron 16 7/8 in. wide serving a workstone. On top of the basin rests a water-jacket, 5 ft. long, 2 ft. 4 in. wide and 1 ft. 4 in. high, consisting of two sections joined at the back by lugs and bolts; the castings are 1 in. thick and have a 4-in. water-space. The back-jackets have eight 1-in. tuyère-holes, 2 in. above the lead of the basin, supplied from a 5-in. blast pipe connected with a 12-in. main. On the jackets rests a small inner hood, while a larger one is suspended from the structure of the building. To the right of a hearth is a small coal-fired lead pot which receives the lead from the workstone, to be roughly drossed and cast into 100 lb. bars. The tools used are a poker, spud, long-handled shovel, a short charging shovel and a ladle. The fuel used is coke. Two men, the charger and helper, work on an eight-hour shift. A hearth treats 7000 lb. ore on a shift; there are produced in winter 24 and in summer 18 bars of 100 lb. in a shift, the coke consumption is about 8 per cent. of the weight of the concentrate.

Slimes, bag-house fume, fine concentrates, raw and roasted matte are treated in ten 12-ton Huntington-Heberlein pots and in two 60-ton Dwight-Lloyd sintering machines; three 26-ft. Godfrey mechanical roasters do the rough-roasting.

There are three blast-furnaces, 40 by 96 in. at tuyères, for smelting gray slag and blast-roasted material; the charges contain 40 per cent. Pb and 17 per cent. matte; the slags made assay SiO_2 32, FeO 30–33,

CaO+MgO 16–19, Zn 8, Al_2O_3 up to 9 per cent., and Pb 0.5–1.3 per cent.; a furnace is run with enough coke to furnish 8.5–9 per cent. C. Two bag-houses take care of the fume. Bag-house No. 1, which receives the fume from the ore-hearth, is 60 by 150 ft., has 6 bays, 1614 cotton bags of Osnaburg sheeting 18 in. in diameter and 26 ft. long, treats 100,000 cu. ft. gas per minute delivered by a 134 by 68 in. fan driven by a 75-h.p. G. E. motor. A flue 12 by 14 ft. and 1794 ft. long delivers the gases to the fan. Bag-house No. 2, which handles all the other fumes, is 61 by 75 ft. has 3 bays and 820 bags. A Custodis circular chimney 160 ft. high furnishes the necessary draft; the foundation is 33 ft. square and 11 ft. deep; the inside diameter of the stack at the base is 15 ft., and 14 ft. at the top; the thickness of wall at the base is 32 in., at the top 7.5 in. For crushing matte there are provided a 9 by 15 in. Farrell crusher and an 18-in. Symons disc crusher. Two liquating reverberatory furnaces with brasqued hearths 6 ft. 2 in. by 7 ft. 8 in., and fire-boxes 3 ft. 9 in. by 2 ft. 7 in., deliver the lead to a 40-ton kettle to be poled with air, skimmed, and siphoned into molds placed on a horizontal rotating casting table.

Smelting at Collinsville, Ill.—The work of this plant of the St. Louis Smelting and Refining Co. is described by H. B. Pulsifer (*Min. Eng. World*, 1913, XXXIX, 681). Galena concentrates from the Mississippi valley are smelted in the ore-hearth and the blast-furnace; the lead is freed from small amounts of impurities and silver by means of the Parkes process, and goes to market as Soft Missouri Corroding Lead. Analyses of the principal lead-bearing materials are given in Table II.

TABLE II. LEAD-BEARING MATERIALS

	Galena Concentrates.	Hearth Fume.	Hearth Slag.	Market Lead.
Pb	68.0	75.0	46.0	99.9986[2]
CaO+MgO	3.0	2.5	9.0	.....
Insol	4.0	5.0	12.5	.....
Cu	0.1	.....	0.5	0.0001
S	14.0	6.0	3.5	.....
Fe	4.0	4.6	10.0	0.0008
Sb	.....	.....	.....	0.0005
Ag[1]	1.0	.....	.....	0.10–0.20

[1] Ounces per ton. [2] By difference.

There are in operation 24 ore-hearths, similar to those of the Federal Works (*q. v.*), placed in two rows of 12, back to back with flues between extending into a horizontal main. A hearth treats in 24 hours 10 tons concentrate and produces 6200 lb. pig lead. Of the lead charged, 55 per cent. is recovered as pig lead, 16 as hearth-slag, and 19 as dust and fume. The fire is started with wood and coal, from 4 to 5 per cent. of coke is mixed with the charge; no lime is used. The gases from the hearth-building pass through cast-iron goose-necks and an elevated flue 600 ft.

long into the bag-house. Three blast-furnaces (35×126 in. at tuyères, 14 ft. high, 7 cast-iron jackets with a 10-in. bosh on a side, and 3 on an end, seven 5-in. tuyères, a forehearth for collecting matte and 2-ton coal-fired kettles for holding lead) treat hearth-slag, ores blast roasted in a 100-ton Dwight-Lloyd sintering machine, heap-roasted bag-house fume, and flue dust briquetted with lime in a Chisholm, Boyd & White machine, to the extent of 120–160 tons charge in 24 hours with a blast pressure of 24 oz.; the slag made is intended to contain SiO_2 29, FeO 37.5, CaO 19.0 per cent. The matte produced is roasted in four long-hearth hand reverberatory furnaces, at the rate of 6 tons in 24 hours with 4 tons of coal and a reduction of S from 19 to 4.5 per cent. A hearth is 14 by 50 ft., and has two fire-boxes 4 ft. 6 in. by 2 ft. 10 in. The lead was formerly softened in 12 hours in a reverberatory furnace with fire-box 8 by 2 ft. and hearth 18 by 11 ft. and 16 in. deep, holding 120 tons of molten lead; there were removed 2.5 per cent. of dross and 1 per cent. of skimming. At present the lead is cleaned in the two 5-ton kettles near the lead-well of a blast-furnace and goes direct to the four 40-ton desilverizing kettles in which the impurities and the 1 oz. Ag per ton are removed by one zincking in from 5 to 8 hours. The desilverized zincky lead is refined in 12 hours in two reverberatory furnaces (hearth 10 by 13 ft. fire-box 2 by 7 ft.) each holding about 55 tons tapped into poling kettles and thence siphoned into molds resting on a casting-wheel.

The zinc-silver-lead crust, with about 650 oz. Ag per ton, is retorted when a sufficient amount has accumulated, in a Faber du Four oil-fired tilting furnace. The retort bullion is cupelled in an English furnace with test 4 by 3 ft., water-cooled at the front.

The gases from the ore-hearths and blast-furnaces are filtered in a bag-house. This is 38 by 78 ft., has 5 bays 14 ft. high, and bags 18 in. by 36 ft. The main fan, 196 in. in diameter makes 75 r.p.m. and handles 200,000 cu. ft. gas per minute. Beside the smelting and refining departments there is in operation a sublimed lead division.

Smelting at Herculaneum, Mo. (H. B. Pulsifer, *Min. Eng. World*, 1913, XXXIX, 1054). Here is situated the smelting plant of the St. Joseph Lead Co.; it treats the lead concentrates from the St. Joseph and Doe Run mills of the company, produces "chemical lead" and a copper-nickel matte, which is sold. The process used is blast-roasting and blast-furnace smelting. Table III gives the character of the ore treated, the blast-roasted sinter, slag and market lead produced.

The galena concentrate is blast roasted in six 42 by 150-in. Dwight-Lloyd sintering machines. The charge is made up to form not only a good blast-roasting mixture, but to furnish a material which can be charged into the blast-furnaces without other fluxes than limestone. The

average composition of the sinter produced is given in Table III. In experimenting, it was found that 50 per cent. Pb in the blast-roasting mixture made the mass too fusible. The charge is ignited with fuel oil.

TABLE III. ANALYSES OF MATERIALS

	Galena Concentrates.	Dwight-Lloyd Sinter.	Blast-furnace Slag.	Chemical Lead.
Pb	64–70	45–47	1.2	.....
S	14	4–45	2.1	.....
SiO_2	2–3	15–17	34.0	.....
FeO	4–6	17–21	34.0	.....
Zn	1–5	.....	4.0	.....
CaO+MgO	3–5	3.5–4.5	10.0	.....
Al_2O_3	.....	.....	3.0	.....
Cu	0.5	.....	.....	0.080
Fe	.....	.....	.....	0.004
Sn+Sb	.....	.....	.....	0.005
Ni+Co	.....	.....	.....	0.002
As	.....	.....	.....	trace

There are three blast-furnaces 42 by 192-in. at tuyères, 66 by 192 in. at the top of the 6-ft. steel jackets, and 84 by 192 in. at the throat. A crucible is 36 in. deep and has two 4-in. siphon taps near the ends; an ore-column is 17 ft. high; there are four jackets on a side, one at each end; the tuyères, 16 in. between centers and 14 in. above the crucible-line, are 4–4.5 in. in diameter. A charge consists of 6000 lb. sinter, 1000 lb. foul slag, the necessary limestone, and coke to furnish 10 per cent. C on the weight of the charge; it is made up in two pits on the furnace floor, hoisted to the feed-floor and dropped from the top of the furnace onto spreaders and plates. A furnace puts through in 24 hours from 250-257 tons charge with a blast-pressure of 24–34 oz. Slag and matte are tapped into a settler; the tapping and stopping rods are 25–40 ft. long instead of the usual 12 ft.; the first matte contains about 3 per cent. Cu; the waste slag is collected in pots of 27 cu. ft. capacity; the slag-sculls assay about 4 per cent. Pb.

The crude lead is liquated in four furnaces having an inclined trough-shaped floor consisting of cast-iron sections bolted together, two working doors on a side, and a water-cooled fire-bridge. The liquated lead runs into four 30-ton kettles where it is poled with steam, skimmed and molded into bars by means of a siphon and two horizontal-table molding-frames. The matte is roasted in Holthoff and Wedge mechanical furnaces. The Holthoff furnace (Power and Mining Machinery Co., Cudahy, Wis., illustrated in *Metallurgie*, 1905, II, 297) consists of a horizontal revolving hearth, 36 ft. in diameter provided with four stationary water-cooled rabble-arms each carrying 12 blades. The ore is fed at the periphery and moved gradually toward four discharge-pockets near the center emptying into two stationary hoppers. In the center is a gas-producer from which the gas enters the hearth through four ports

and burns; the hot gases traveling in a direction opposite to that of the ore are drawn off through small pipes in the stationary roof into an elevated main connected with a suction fan. About 40 tons matte are roasted in 24 hours with a reduction of the S content from 24 to 10 per cent.

The Wedge furnace has seven superimposed hearths 20 ft. in diameter; four oil-burners are used to start the operation or to assist the roast in case of necessity; usually one or perhaps two are employed. The furnace treats 60 tons matte in 24 hours reducing the S content from 24 to 10 per cent. (The same furnace is doing similar work at the Midvale plant of the U. S. Smelting, Mining and Refining Co., Editorial, *Eng. Min. Jour.*, 1913, XCVI, 992.) A bag-house is in process of construction. It is 56.5 by 216.5 ft., has 16 bays, a thimble-floor 16 ft. high, four bag-rooms with 2496 bags 18 in. in diameter and 30 ft. long, made of 48 by 48 mesh cotton cloth. The suction fan, 16 ft. in diameter, handles 140,000 cu. ft. gas per minute at 203 r.p.m., and gives a depression of 2 in. water. The sheet-iron ballon flue leading to the bag-house is curved on a 12-ft. radius and has 45-degree hoppers. The stack is 300 ft. high and 20 ft. inner diameter.

Smelting at Trail, B. C.—Some changes that have been made at this smeltery are recorded by E. Jacobs (*Met. Chem. Eng.*, 1913, XI, 562). There are in operation at present 7 Huntington-Heberlein mechanical rough-roasting furnaces, which are being supplemented by two Wedge mechanical roasters. The 36 Huntington-Heberlein pots have been rearranged and placed in 4 rows of 9 each. A Hayward clam-shell bucket serves to raise the sinter cakes and to deliver them to a 24 by 36-in. Farrel crusher. A gas-producer plant is being installed to provide gas for all the roasting furnaces. Three new blast-furnaces 45 by 216 in. at tuyères and 17 ft. 6 in. high are being erected.

Smelting Cyanide Precipitate at the Pittsburgh Silver Peak Mill, Blair, Nev.—(Smith, *Eng. Min. Jour.*, 1913, XCV, 603.) The gold precipitate obtained from cyanide solution by the use of zinc dust, is dried after it has been treated with sulphuric acid and washed; 100 parts are mixed with 125 litharge, 25 borax, 15 soda, and 4 coke, and briquetted under a pressure 1000 lb. per sq. in. The briquettes are smelted in a small water-jacketed blast-furnace, 22 in. in diameter at tuyères and 5 ft. 10 in. high. In blowing in, the crucible provided with an Arents siphon tap, is filled with 200 lb. lead. The regular charges are briquettes 100 lb., slag 30 lb., cupel-bottom 7, furnace-crust 7, coke 30 lb. A run, excluding the 3 hours required for blowing in, lasts about 18 hours, in which time there are fed 18 charges and 2500 lb. coke. The products are, lead bullion 1780 lb., cast into bars weighing about 27 lb., matte 257 lb., slag 3500 lb., crust 360 lb. The cupellation of the lead is discussed below.

Smelting at Binsfeldhammer Works, Stolberg.—(*Zt. angew. Chemie*, through *Min. Jour.*, 1913, CII, 900.) The ores treated are galena concentrates with Pb 65–72, Zn 5–8, S 13 per cent., and Ag 17–26 oz. per ton; they are mixed with fluxes in a Raps revolving barrel, which treats 140 tons in 8 hours with an expenditure of 4.5 h.p., and rough-roasted in four furnaces of the Brunton type, 20 ft. in diameter. The rough-roasted ore contains 2–3 per cent. sulphide-S and 6–7 per cent. sulphate-S and the gases 0.2–0.3 per cent. S. The rough-roasted ore is blast-roasted in von Schippenbach furnaces (MIN. IND., 1911, XX, 480) at the rate of 40–50 tons in 24 hours per furnace; the roast-sintered ore contains 1–1.5 per cent. sulphide-S and 2.25 per cent. sulphate-S. The gases are separated into two parts of 90 per cent. with 4–5, and of 10 per cent. with 0.6–0.7 per cent. (vol.) SO_2; the former are cooled, filtered and forced into a Schröder-Grillo contact-plant, while the latter after further dilution pass off into the open. The blast-roasted material is smelted in two blast-furnaces 10 by 3.3 and 13 by 3.3 ft. at the tuyères at the rate 250–260 and 250–350 tons in 24 hours, with 7–7.5 per cent. coke. The lead bullion assays from 35–43 oz. Ag per ton; the slag analyzes SiO_2 28, FeO + MnO 32, CaO 16–17; ZnO 11–12, Al_2O_3 7, Pb about 1 per cent. The lead-bullion is desilverized by the Parkes process in 60-ton steel kettles; the zinc crust is freed from Ag by a special process in which the Zn is converted into marketable oxide with Zn 62–63 per cent.

Smelting at Blagodatny, Ural.—(Ortin-Lange, *Metall u. Erz*, 1913, X, 799, 835, 874.) The ores are silver- and gold-bearing mixed sulphides of lead, copper and iron in a siliceous gangue. They are concentrated and treated in a lead and a copper department. The lead concentrate contains Pb 30–35, Cu 8–10, Fe 8–10, S 16–17, SiO_2 20–24, Zn 1.5–2, Sb 1.0–1.5, As 0.4–0.6 per cent., Au 1.05–1.37 and Ag 38.0–45.6 oz. per ton; it is mixed with 5 per cent. coke and blast-roasted direct in a pot 3.3 ft. in diameter. From 3–4 per cent. of the change remains pulverulent. The sintered cake contains 9–10 per cent. S. As this is too high, the cake is broken and heap-roasted whereby the S content is reduced to 4–5 per cent. The blast-roasted ore mixed with copper refinery slag (Cu 10–12, Pb 20–30, Fe 12–14, SiO_2 22–26 per cent., Au 0.15–0.38 and Ag 7.41–11.37 oz. per ton), raw galena concentrate, iron ore (SiO_2 20, Fe 45 per cent.) and limestone (CaO 52 per cent.), and smelted in a circular water-jacketed blast-furnace (30.3 in. in diameter at tuyères and 72.8 in. at throat, height 13.2 from tuyères to throat) with bottom tap, for lead bullion (Pb, 90–95 per cent.), lead-copper matte (Cu 30, S 20, Pb 15, Fe 34, undetermined 1 per cent.), and slag (SiO_2 36.2, FeO 34.0, CaO 19.8, undetermined 10.0 per cent.); the coke consumption is 15.7

TABLE IV. ANALYSES OF PRODUCTS OF BLAGODATNY.

	Lead Bullion.					Matte.			Speiss.		Slag.		
	1	2	3	4	5.	6	7	8	9	10	11	12	13
Au[1]	9.259	9.4013	20.577	9.0988	4.7192	0.2397	0.0872	0.1527	115.26	116.02	0.0075	0.1526	0.1526
Ag[1]	131.97	140.32	159.29	134.24	109.22	30.087	11.954	26.845	67.929	206.72	0.2712	0.9648	0.45499
Cu	0.31	0.51	0.50	0.40	0.43	26.7	41.7	32.64	20.9	12.37	0.37	0.73	0.35
Pb	95.76	90.92	88.5	91.75	95.56	13.50	20.14	20.11	30.08	2.92	1.90	1.0	0.55
Fe	0.02	0.01	0.01	0.02	0.03	30.46	15.28	22.06	0.72	42.0			
S						22.49	21.6	21.09	1.56	2.86	34.25	35.70	33.90
SiO_2						0.28	0.04	0.10			7.10	?	6.95
Al_2O_3											36.24	33.7	33.9
FeO											18.80	19.0	20.12
CaO									28.43	9.28			
Sb	2.72	6.32	9.13	5.95	3.79				3.16	30.5			
As		0.11	0.20	0.13									
Bi	0.18	0.43	0.30	0.274	0.10				12.05				
Ni													

[1] Av. and Ag values are in oz. per ton.

per cent. The yield of Au is 94.7 per cent., that of Ag 75.8 and that of Pb 82.3 per cent.

Table IV gives analyses of the products obtained.

Early Example of Blast Roasting.—Vassiliadi (*Bull. Inst. Min. Met.* No. 104, through *Metall u. Erz*, 1913, X, 792; see also MIN. IND., 1912, XXI, 545) records an early example of blast-roasting practice at the Balia mines in Asia Minor in 1895. A concentrate with Pb 19.15, SiO_2 7.47, Fe 23.67, CaO 0.80, Zn 6.59, and S 35.18 per cent. was treated in a so-called Pelaton furnace, an oblong structure (9.5 ft. long, 3.0 ft. wide and 3.3 ft. deep with grate and undergrate blast), enclosed at the sides and back by iron plates and at the front by a water-jacket. The ore treated raw gave a sinter with Pb 20.25, SiO_2 14.50, S 17.50, Fe 27.09, CaO 1.10; if first roasted in a Maletra furnace to reduce the S content to 10 per cent., the product of the blast-roast was changed to Pb 27.60, SiO_2 11.34, S 2.20, Fe 36.00, CaO 1.20.

Blast Roasting at Zeehan, Tasmania.—Levings (*Bull. Inst. Min. Met.*, through *Min. Eng. World*, 1913, XXXVIII, 764) discusses the operations of blast roasting at the works of the Tasmania Smelting Co., Zeehan, Tasmania. The Huntington-Heberlein process was introduced in 1900. At first 2-ton conical pots were employed, later they were replaced by pots holding 8-ton charges. In the working it was found that coarse limestone (12 mm.) worked as well as fine, also that limestone was not es-

sentia to success, in fact, that in the absence of limestone less material remained pulverulent at the end of a blow than when limestone was used. Experiments also showed the importance of moistening the charge and of not allowing the S-content to exceed 10 per cent. The paper records some blast-roasting work carried on with a pyritic ore containing tin.

Laboratory Apparatus for Blast Roasting.—Such an apparatus has been constructed by H. B. Pulsifer (*Eng. Min. Jour.*, 1913, XCVI, 308; see also apparatus of Hahn, MIN. IND., 1911, XX, 481) which consists of a small pyramidal cast-iron pot 8 in. high and 8 in. wide at the top, which has 4 in. from the top a shoulder to support a perforated cast-iron plate 6.5 in. sq. and 0.5 thick, to serve as grate. Air is supplied by a motor-driven fan with delivery pipe 6 in. in diameter reduced to 3 in., the opening of the air inlet. Excelsior or sawdust ignited with a match may be used to heat the charge, but an oil-burner is preferable. Two or three Bunsen burners have given the reviewer satisfactory results.

Dwight-Lloyd Sintering Machine at Cerro de Pasco, Peru.—In blast roasting at the elevation of 14,000 ft., Lloyd (*Min. Sc. Press*, 1913, CVI, 908) found that the ignition flame had to be hotter, that the charges could bear a higher sulphur content (as much as 25 per cent. S with pyritic ore), and that the speed of roasting was slightly lower than at lower elevations. The slowness of oxidation at high elevations was further noticed by the fact that the flowers of sulphur which collected in the fan when treating pyritic ore, did not ignite. The reverse of this took place recently at Midvale and Tooele, Utah (Editorial, *Met. Chem. Eng.*, 1913, XI, 426) where the sulphur and flue dust ignited, caused an explosion, and destroyed part of the dust flue and a large number of filter bags. Such accidents are now avoided by measurement of temperatures of the flue and allowing the gases to pass into the open when the pyrometers indicate that the ignition temperature is being approached.

Mechanical Grate-cleaner.—Under ordinary conditions of working it is necessary to keep a man at the discharge end of a Dwight-Lloyd machine to remove from the grates by punching any parts of the sinter which are not dislodged by the shock when a pallet after passing over the guide strikes the one that preceded it. This man has been made unnecessary (Editorial, *Eng. Min. Jour.*, 1913, XCVI, 989) by casting grates with slots running parallel to the longitudinal axis of the machine and installing a mechanical cleaner. This consists of a series of ordinary washers which are strung upon a rod and kept apart by separating rings in such a manner that the washers register with the slots in the grate. The grate lifts the rod with its washers and causes it to fall in one row of slots which are thus effectively cleaned. With the next movement of the grate, the rod is

again lifted, when upon falling the washers strike into the next row of slots, and so on.

Von Schippenbach Blast-roasting Furnace.—An excellent photograph of the von Schippenbach down-draft blast-roasting furnace at the Binsfeldhammer lead works of the Rhein-Nassau Co. is given in the *Eng. Min. Jour.*, 1913, XCV, 1061. The leading features of this furnace have already been given (MIN. IND., 1911, XX, 480).

Blast-furnace Waterjackets.—H. C. Holthoff has patented (U. S. Patent No. 1047055, Dec. 10, 1912) a water-jacket of forgable iron in which stress is laid upon having the curvature at the corners on large diameters in order that the expansion, especially on the inner or fire-sheet, may be readily taken up.

Measurement of Blast and Gases.—The measurement of the volume of blast or flue gases by means of the Pitot Tube is discussed by McQuigg (*Eng. Min. Jour.*, 1913, XCV, 649), Richards (*op. cit.*, 1913, XCV, 768), Dunn (*Trans. A. I. M. E.*, 1913, XLVI), and Rouse (*J. Am. Soc. Mech. Eng.*, 1913, XXXV, 1319; *Met. Chem. Eng.*, 1913, XI, 641).

Lead-Copper Matte.—The recovery of lead and copper by ordinary smelting operations is connected with some difficulties. Laboratory experiments carried on by Menzel (*Metall u. Erz*, 1913, X, 193, 230; *Eng. Min. Jour.*, 1913, XCV, 902) aim to increase the direct yield of lead. They show (1) that the "top and bottom" process effective in separation of Fe and Cu from Ni sulphide gives no satisfactory results in separating a copper top from a lead bottom; (2) that PbS is decomposed by fusion with CaO and C, there being found CaS and Pb, the direct yield in Pb reaching 70 per cent., while the remaining PbS forms with the CaS a solid solution; (3) that additions of CaO, $CaSO_4$ and $BaSO_4$ in decomposing PbS by means of Fe reduce the normal yield of Pb; (4) that in smelting with CaO and C there is liberated some Cu as metal from Cu_2S and from copper matte. The process proposed embodies the crushing of matte (*e.g.*, matte from Otavi with Cu 41 and Pb 23 per cent.) to 2 mm., mixing with CaO and smelting in a reverberatory or electric resistance furnace when there will be found lead bullion (17 per cent. with Pb 90 and Cu 5 per cent.), copper matte (75 per cent. with Cu 40 and Pb 8 per cent.) and speiss (8 per cent. with Cu 50 and Pb 3 per cent.). The lead is to be freed from most of its Cu by liquation, the copper matte is to be roasted and smelted in a reverberatory furnace for blister copper, the speiss is to be decomposed by an oxidizing fusion in a reverberatory furnace, furnishing metallic copper to be granulated and treated with sulphuric acid, and refinery slag to go to the ore furnace.

Magnetite in Matte and Slags.—This subject is discussed by Walter (*Eng. Min. Jour.*, 1913, XCV, 213) and Bennie (*op. cit.*, 1913, XCVI,

1213), and incidentally by Wright (*op. cit.*, 1913, XCVI, 825). Walter records the statements of Collins, Hofman and Peters which give the facts, but do not try to explain them; coming to Roberts-Austen, the formation of Fe_3O_4 is explained by the theory that in a molten ferrous silicate with less than 30 per cent. SiO_2, the excess-iron, when exposed to the air, is gradually oxidized to Fe_3O_4. The author then builds up a theory based on the assumption that the formation temperature decreases with the silicate-degree, which is contrary to facts (Hofman, "General Metallurgy," 1913, p. 455). Bennie found in smelting sulphide copper ore in the blast-furnace that a decrease in temperature at the tuyère-level caused the formation of Fe_3O_4; he holds further this formation is due to the reactions $3FeS+10O=Fe_3O_2+3SO_2$ and $FeS+10Fe_2O_3=7Fe_3O_4+SO_2$. Wright, finally gives reasons for believing that the preceding reaction is preferable to the following $FeS+3Fe_2O_3=7FeO+SO_2$ which is usually given in the technical literature. The reviewer believes that the statement of Roberts-Austen comes nearer the truth than any other. In a reducing assay-charge for Fe_2O_3, *e.g.*, the formation of Fe_3O_4 is easily controlled by the percentage of SiO_2, because as long as you form a bisilicate no Fe_3O_4 is found in the slag. (Professor E. E. Bugbee, Institute of Technology, Boston Mass.) In an oxidizing fusion as in the convertion of matte, Fe_3O_4 forms as soon as there is lack of SiO_2; in fact Wheeler and Krejci (*Bull. No.* 84, *A. I. M. E.*, 1913, p. 2769) have based the coating of the basic converter with magnetite upon this absence of SiO_2, and control the thickness of the lining by the percentage of SiO_2 of the charge and the temperature of the vessel. From this it appears that the formation of Fe_3O_4 in a slag, and with this in the matte, is governed by the percentage of SiO_2 of the slag, and the latter to some extent by the formation temperature.

Slag Temperatures.—The temperatures of slags flowing from blast-furnaces are usually judged by the eye. Clevenger (*Met. Chem. Eng.*, 1913, XI, 448) measured the temperatures of the following lead blast-furnace slags as they flowed from the tap-hole: (1) SiO_2 34.0, FeO 30.5, MnO 3.7, CaO 15.0, MgO 1.3, Al_2O_3 6.4, ZnO 7.2 per cent., 1170° C.; (2) SiO_2 32.0, FeO 31.0, MnO 3.8, CaO 14.5, MgO 1.3, Al_2O_3 6.6, ZnO 7.2 per cent., 1149° C.

Ferrous Silicates.—Zmiel (Review, Russian Metallurgical Society, 1912, pp. 783–796, through *Rev. Mét., Extr.*, 1913, X, 611) studied the freezing points of a series of ferrous silicates; the compositions ranged from SiO_2 14.51, FeO 79.09 (Fe_2O_3 6.80) freezing at 1280° C., to SiO_2 56.97, FeO 39.17 (Fe_2O_3 3.51), freezing at 1105° C.; a eutectic halt was noticed at 1170° C. Owing to the varying amounts of Fe_2O_3 present, there is little regularity in the data obtained.

Ferro-Calcic Bisilicates.—The system $FeSiO_3$-$CaSiO_3$ has been studied thermally and microscopically by N. S. Konstantinoff and B. P. Selivanoff. (Review Russian Metallurgical Society, 1912, pp. 767–782, through *Rev. Mét., Extr.*, 1913, X, 607.) They find that there exists three solid solutions α, β and γ, that γ-crystals occur between pure $FeSiO_3$ and 10 per cent. (mol.) $CaSiO_3$; that the freezing point of $FeSiO_3$ lies at 1150° C.; that α crystals are found between 44 and 65 per cent. (mol.) $CaSiO_3$, and that these limits converge as the temperature is lowered, that between α and β there exists an eutectic with 25 per cent. $CaSO_3$ freezing at 1030° C.; that γ crystals between 85 and 100 per cent. are solid solutions; that transition points occur between β and γ crystals.

Slag Tables.—Konstantinoff (Review, Russian Metallurgical Society, 1913, p. 100; through *Rev. Met., Extr.*, 1913, X, 609) gives a table showing the melting points of the leading silicates formed in metallurgical practice, to which are added the methods of determination and the names of the authorities.

Condensation.—Removal of vapor and dust in lead and zinc works. A few apparatus, and especially that of Baraduc Müller, are discussed and described by Gerold (*Rauch and Staub*, 1913, III, 315). The principle of operation is the creation of a vacuum of about 1 mm. of mercury; it is therefore applicable only to small vessels.

Filter-bag.—F. G. Gottrell patented (U. S. Patent No. 1060065, April 29, 1913; *Eng. Min. Jour.*, 1913, XCVI, 406; *Met. Chem. Eng.*, 1913, XI, 347) a process for making cotton bags resistant to sulphurous gases in which he heats the cotton out of contact with air to 150–200° C. This carbonization decreases the tensil strength of the cotton and makes it brittle, but not sufficiently so to prevent producing a fabric which has sufficient strength to act as a filter in a bag-house; however, it makes it resistant to acids. The intention is to carbonize bags woven in one piece and then use them in the bag-house.

Wet Condensation.—C. Herwegh (*Met. Chem. Eng.*, 1913, XI, 399) read a paper upon the Feld gas washer (MIN. IND., 1912, XXI), in which he gives data obtained at a French blast-furnace plant. The paper contains details of a proposed American installation.

Cottrell Electric Precipitation.—A paper by L. Bradley (*Proc. Eng. Soc. West, Pa.*, April, 1913; *Eng. Min. Jour.*, 1913, XCVI, 247) gives the progress that has been made with this process in different establishments. At the works of the Raritan Copper Co., Perth Amboy, N. J. (drawing in Hofman, "Metallurgy of Copper," 1914) the scrubbed gas from the reverberatory furnace in which the acid-treated anode mud is smelted, is passed through a Cottrell apparatus. The recovered sludge runs high in silver and very low in gold. At the Garfield smeltery (Hofman, *op.*

cit.) the converter gases carrying much lead fume pass through a Cottrell condenser which recovers 98 per cent. of the values; experiments with gases from the MacDougall, blast and reverberatory furnaces have given promising results at the lead smeltery of the Ohio and Colorado Smelting and Refining Co., Salida, Colo. Experiments with gases from the Dwight-Lloyd sintering machines and the blast-furnaces have given favorable results.

Ammonia in Flue Dust.—Attention has been called to the presence of NH_3 in flue dust which becomes noticeable when the dust is being mixed with slaked lime preparatory to briquetting. Dwight (*Trans. A. I. M. E.*, 1912, XLIII, 746) noticed this phenomenon as did Semple (*Eng. Min. Jour.*, 1913, XCV, 1208). J. W. Richards (*Trans. A. I. M. E.*, 1912, XLIII, 748) suggests that nitrides, especially AlN, may be the source of NH_3, but nothing definite is known about it.

Lead Poisoning.—Part VIII of the report of the commission appointed by Austrian Secretary of Commerce to study lead-poisoning in industrial plants (MIN. IND., 1906, XV, 533; 1909, XVIII, 502) has appeared; (Hölder, Vienna, 1913, 4to, 136 pages) it deals mainly with the ceramic, glass and enamel industries.

Experiments by Lewin (*Metall u. Erz*, 1913, X, 441) show that molten lead does not give off any vapor at 500–520° C., but that some vapor may be noticed between 850 and 900° C., and that the presence of other metals, especially of zinc, reduces the temperature at which vapors form. The bad effects of lead upon workmen are usually caused more by dust than by vapor, and the dust should be withdrawn by suction fans or other ventilating devices.

J. Libert and V. Firket have published a monograph (*Ann. Mines Belgique*, 1913, XVIII, 449–519; reprint published by Béranger, Paris-Liége, 1913) upon the progress that has been made in the lead and zinc works of Belgium since 1898, especially during the period of 1901–1910, in rendering less harmful the bad effects of dust and fume. They describe and illustrate the means employed for removing dust and fume, the arrangements provided for bathing and changing of clothing, give the rules to be followed by managers and workmen, and advocate the periodic examination of the men by physicians.

Damage of Furnace Gases.—A paper by Hasenbäumer (*Rauch und Staub*, 1913, III, 109) gives many valuable analytical data to show that the damage done to vegetation by sulphurous gases can be easily recognized by the S content of the plants. The examination of the soil for its sulphur content as a rule is of little importance, although in some instances with oaks and beeches the S content of the barren soil near the trunk gave higher values in S than the soil some distance off covered with moss.

A report by Hanning-Hempel-Schiffner-Wislecenus accompanied by 18 plates, upon the damage done to some forests in Saxony by the gases issuing from brick-kilns, has been issued by the Treasury Department of Saxony (Freiberger Jahrbuch, 1913, pp. 47–87); the reference to it is all that can be given here.

Reduction of Sulphur Dioxide.—Young (*Eng. Min. Jour.*, 1913, XCV, 369) in a review of the present status of the Thiogen Process (MIN. IND., 1912, XXI, 559), states that certain difficulties encountered in experiments on a practical basis have been overcome, and that the others still remaining are not sufficiently great to endanger the ultimate success of the process.

PARKES PROCESS

Zinc-Silver Alloys.—The zinc-silver alloy series has been studied by Carpenter and Whiteley, (*Int. Zeits. Metallog.*, 1913, III, 145; *Jour. Inst. Metals*, 1913, IX, 214) who have come to results differing radically from those of Petrenko (MIN. IND., 1911, XX, 493). Their diagram resembles that of the copper-zinc and silver-cadmium series of alloys (Carpenter, *Int. Zeits. Metallog.*, 1913, IX, 191). They found six constituents; the first, a solid solution α with from 0 to about 33 per cent. by weight of zinc, is stable at ordinary temperature; the β solution, extending from about 33 to about 53 per cent. zinc, is stable only above 264° C., below which it undergoes a eutectoid transformation into $\alpha+\gamma$; the next constituent is found at 48 per cent. zinc as the compound Ag_2Zn_3, freezing at 665° C.; near it comes the second compound Ag_2Zn_3 freezing at 636° C. which forms solid solutions on the zinc side; there exists an ϵ constituent, stable only at high temperatures which splits into δ and η at lower temperatures. Zinc forms solid solutions with not more than 1 per cent. silver.

Lead Refining at South Chicago.—H. B. Pulsifer (*Min. Eng. World*, 1913, XXXIX, 153, 205) furnishes a general description of the "National" plant of the American Smeltery and Refining Co., situated in South Chicago, which confines its work to zinc desilverization of lead bullion and the working of the resulting product. Only some of the leading features will be touched upon. The lead bullion is transferred mechanically from the railroad car into the softening furnace by means of a movable inclined motor-driven steel conveyor which elevates the bars from an easy carrying-height in the cars to above the level of the furnace-door, from which they glide down a curve chute into the side-door next to the fire-place. The temperature in the furnace is kept sufficiently high for the bars to melt about as quickly as they are delivered. A furnace

135 tons capacity is thus charged by four men in from 2 1/2 to 3 hours. There are three softening furnaces with capacities of 80, 125 and 135 tons lead bullion, the larger furnaces treat Western lead, the smaller ones the product of the works. The molten bullion is drossed in about 2 hours after the charging is finished, the dross weighing 3 per cent. of the weight of the charge. Litharge is added to the drossed lead in order to assist in the oxidation of As and Sb. The skimming drawn amounts to about 5 per cent.; softening takes from 16 to 20 hours, and requires about 4.5 per cent. Illinois coal.

There are three desilverizing kettles holding 55, 65 and 75 tons of softened bullion; a softening furnace can discharge into two kettles. The life of a kettle is about 400 charges. The precious metals are extracted to 0.15 oz. per ton by two zinckings in about 18 hours; the zinc is stirred in with a Howard stirrer, and the crust is freed from excess lead in a Howard press; the unsaturated slabs of zinc-silver-lead alloy are raised from the floor, on which they had been formed in skimming the kettles, by compressed-air lifts when they are to be returned to the kettles. The desilverized lead is freed from its 0.65 per cent. zinc in two coal-fired reverberatory furnaces of 110 and 96 tons capacity; a third, oil-fired, 80-ton furnace is held in reserve. The oxidation of the zinc is hastened by air-pipes passing through the water-jacketed sides of the pan holding the brick lining. Refining lasts about 8 hours, the skimming formed amounts to 3.5 per cent. of the weight of the charge; about 1.5 tons coal is required. The refined lead, about 94 per cent. of the bullion charged, retains about 0.01 per cent. zinc. An analysis shows: Pb 99.8979, Sb 0.0053, Cu 0.0052, Bi 0.0783, As trace, Zn 0.0089, Fe 0.0040, Ag 0.0004. The market lead is cast from the refining furnace by being made to flow through an L-shaped pipe with regulating cock into a trough provided with five spouts of iron pipe and suspended at the opposite end from a compressed air lift. In front of the spouts is a link-belt chain which moves on rails the carriages carrying the lead molds; the flow of lead from the spout is regulated by raising or lowering the inlet-end; the bars are skimmed and trimmed by one operator while the other regulates the flow; the carriages deliver the solidified lead bars onto a truck.

The saturated zinc-silver crust, assaying 2000–4000 oz. Ag per ton, is broken while hot, charged into 1000-lb. oil-fired retorts, which distil off 200 lb. zinc in 6 hours; the condenser used is an old retort. The retort-bullion retains 1.25 per cent. zinc; about 80 per cent. of the zinc is recovered as spelter, the rest forms blue powder which is prepared for the market and sold. The plant has eleven retort furnaces. The three cupelling furnaces are coal-fired and have Rhodes tilting test-supports; a test has a perforated cast-iron bottom, water-cooled plate-iron sides,

receives a bottom lining of slag-limestone mixture and a working lining made up of Portland cement and bottom mixture; the ramming is done with compressed air tamping irons. The softening furnace dross is smelted in a reverberatory furnace, having water-jacketed sides, with Mississippi valley galena, for matte with 30 per cent. Cu and 60 oz. Ag per ton, and lead bullion; softening furnace skimmings are smelted with coal in a similar reverberatory furnace for clean skimmings and lead bullion; the clean skimmings are smelted in a blast-furnace 46×96 in. at tuyères for hard lead with 15–20 per cent. Sb.

Lead Refining at Omaha.—An outline of the work carried on in the refining department of the Omaha plant of the American Smelting and Refining Co., is given by H. B. Pulsifer (*Min. Eng. World*, 1913, XXXIX, 457). This is the largest refinery of the country treating from 10,000 to 16,000 tons lead bullion a month. The Parkes process and the Tredinnick modification of the Pattinson process (MIN. IND., 1900, IX, 457; 1902, XI, 851; 1907, XVI, 689; 1908, XVII, 605) are in operation; only the former is described. The cars bringing lead bullion are run directly to the softening furnaces and unloaded, if the sample bar has been accepted by the two parties; in case the shipment has to be sampled at the refinery, it is unloaded into a 40-ton kettle, melted, sampled, tapped into pots, trundled to softening furnaces and poured. There are five softening furnaces in a row which are supplied with lead bullion by two charging machines similar to those in use at South Chicago; one furnace holds 220 tons lead, three 280 tons, and one 300 tons. There are tapped from a softener 200 tons of softened bullion to fill three desilverizing kettles. The sides of the furnaces are water-jacketed, the lining is of hardburnt fire-brick. Softening of lead is assisted by the addition of litharge if the lead does not give up its arsenic and antimony in the desired time. The six desilverizing kettles are elliptical and hold 80 tons lead bullion; zinc is incorporated in a kettle by means of duplex Howard stirrers, the crusts are handled in Howard presses, one to a kettle, holding 1.5 tons crust; 1 ton of zinc yields about 3 tons of first or saturated crust. The refining furnaces are duplicates of the softeners, a furnace receiving its charge from three kettles; steam is used to assist in the oxidation of the zinc retained by the desilverized lead; the oxide is removed as a powder. The refined lead is run into holding furnaces from which it is cast at the rate of 25 tons per hour in a manner similar to that in South Chicago. It differs from it in that the link-belt conveyor moves continuously. When six molds have been filled, the swinging trough is moved back the required distance. As the holding furnace has a smaller capacity than the refining furnace, it receives the latter's charge in several parts. Copper dross and antimony skimming are smelted in the usual way in 50-ton rever-

beratory furnaces. The silver crusts are treated in 12 retorts arranged in two groups of six, a retort being fired by two oil-burners. The retort bullion is cupelled in three furnaces. Doré silver is parted with sulphuric acid in oil-fired cast-iron kettles, each holding 10,000 oz. The plant has three blast-furnaces 48 by 140 in. at tuyères (seven on a side) and 18 ft. high, for lead-charges, and one circular furnace 36 in. in diameter and 13 ft. high for copper charges. There are two basic barrel converters for treating the lead-copper matte from the blast-furnaces. The collection of dust and fume was treated last year by A. Eilers (MIN. IND., 1912, XXI, 555).

Water Jackets in Softening Furnace.—All softening furnaces have water jackets on the sides and ends. This practice was inaugurated by E. Balbach, Jr. in 1873 (U. S. patent No. 141912, August 19, 1873) who jacketed also the bottom of the pan holding the hearth; bottom-cooling, however, has been given up by most refiners, as it is unnecessary and retards the heating of the lead.

The Removal of Tin in Softening.—The softening of lead bullion, freed from most of its copper previous to desilverizing by means of zinc is usually accomplished by an oxidizing fusion whereby tin, arsenic and antimony are removed in the order given. In the process patented by B. C. Besley (U. S. Patent No. 1060527, April 29, 1913), the lead bullion is liquefied in a bath of salt, litharge is added to oxidize the tin and combine with the oxide to form a crust which is then smelted for lead-tin solder.

A patent (U. S. Patent No. 1060527, April 29, 1913; *Met. Chem. Eng.*, 1913, XI, 346) has been granted to Howell for the separation of tin from lead.

Casting of Lead.—The use of a centrifugal pump for the removal of lead from a kettle (Hofman, *Eng. Min. Jour.*, 1913, XCV, 98; Miller, *op. cit.*, 1913, XCV, 386) originated with J. F. Miller at Trail, B. C., was later adopted at Grasselli, Ind., and is replacing the Steitz siphon in many lead plants. At Trail there is in operation an iron Rumsey vertical submerged centrifugal pump, No. 3, (Rumsey and Co., Ltd., Seneca Falls, N. Y.) which has a suction of 2.5 in., and a discharge of 2.5 in., is rated at 150 gal. water per minute, and costs $55. The pump is run at from 400 to 500 r.p.m. depending upon the amount it is desired to raise in a given time. At Grasselli a similar pump 8 in. in diameter with a 2-in. discharge is in operation. In order to have an even flow of lead, the vertical stand-pipe in which the lead rises has a special discharge opening in the side. By keeping the lead in the pipe above the discharge opening, there is an even flow through the molding pipe which fills the molds uniformly and does away with splashing or slopping.

Cupellation at Pittsburgh Silver Peak Mill, Blair, Nev.—(Smith, *Eng. Min. Jour.*, 1913, XCV, 603.) The lead bullion to be treated is that obtained by the smelting of zinc precipitate with litharge and fluxes in the blast-furnace (see p. 466). The test is 2 ft. 10 in. long by 2 ft. 6.5 in. deep; the test material is made up of a mixture 450 lb. Portland cement and 150 lb. limestone crushed to pass a 20- to 30-mesh sieve, to which is added 14 per cent. of water; the blast is furnished by a Connersville blower having a displacement of 3.25 cu. ft. air per revolution; the blast-pressure is from 3 to 5 oz. per sq. in.; oil serves as fuel. A typical run is about as follows: heating-up, 12 hours; melting, 6 hours; cupelling 1680 lb. lead, 18 hours. The gold bullion is melted and refined with borax in a No. 60 Donaldson oil-fired tilting crucible furnace and yields bars with a fineness of 0.635 Au and 0.315 Ag.

Cupelling at the Works of the Black Mountain Mining Co., Cerro Prieto, Sonora.—Mexico (Munroe, *Eng. Min. Jour.*, 1913, XCV, 1137). An oil-fired cupelling furnace serves both for smelting the precipitate and cupelling the lead bullion, as is the case in the Taverner process (MIN. IND., 1902, XI, 323; 1903, XII, 251). The precipitate taken from the Merrill press containing from 35–41 per cent. H_2O is placed in pans holding 225 lb., and then heated in a drying furnace which reduces the moisture to about 10 per cent. This material, assaying now AuAg 35–45, Zn 25–35 and Pb 10–20 per cent. is mixed with 90–120 per cent. litharge, 30 old slag, 10–20 borax glass, 30–20 assay slag, 5–8 coke, 8–15 SiO_2 and 5 per cent. Na_2CO_3, and tied up with a double layer of old filter cloth into packages weighing from 6–8 lb. The cupel-test is an oval ribbed casting 44 in. long, 36 in. wide in the middle and 8 in. deep; the breast, 16 1/4 in. wide, has a cavity 4 1/4 in. deep for the litharge gutter. The test is suspended at the front by a modified Lynch support, the bottom has forty-seven 3-in. holes. The bottom lining for smelting is made up of 100 lb. limestone (20-mesh), 180 fireclay, 60 Portland cement and 60 lb. old test bottom (20-mesh); that for cupelling of 156 lb. limestone (20-mesh), 156 fireclay, 52 Portland cement and 52 lb. old bottom (20-mesh). Mixture, either for smelting or cupelling, is screened into the test until this is filled, then trodden, rammed with 20-lb. tampers and finished with 8-lb. hammers.

For melting, two protecting cast-iron liners 1/2×6×8 in. are placed toward the breast and wedged in place by means of a 2-in. wooden plug, the space of which is to be filled later on with bone-ash; similar liners 15×4 in. are placed against the back. More lining material is now rammed in to furnish a cavity, 7.5 in. deep at the front, which rises to near the back liners. A cast-iron plate with slot is bolted to the front to serve as tapping-plate for lead. For cupelling, no liners are used.

The cavity is 4.25 in. deep, the rim of the test material at the front is 4 in. wide, at the back and sides 1.25 in. A water-cooled breast-jacket is screwed to the front to serve as support of the litharge gutter.

In starting, 2 bars of lead are melted down; the bath of lead receives the packages of charge which are introduced first one at a time and later in increasing numbers. When the test has been filled, a groove is cut in the bone-ash plug, the front of the test lowered, and a pot of slag drawn. The test is raised, the groove filled with bone-ash (moistened with H_2O containing 20 g. $NaNO_3$ per liter), more charge given, and slag drawn at 1 1/2-hour intervals. When 5–6 pots of slag have been drawn, enough lead has been reduced to fill the cavity. The test is now raised, 5–6 lb. ground slag are placed back of the breast to hold back fluid slag, and about 160 lb. lead bullion (= 2 bars) allowed to flow through the tap-hole opened 2 in. above the bottom. This leaves behind about 300 lb. lead to serve as a bath. Fresh charges are given, and 2 bars lead bullion tapped after two pots of slag have been drawn. When the charge to be smelted has been introduced and the last pot of slag drawn, the test is raised at the front, the cast-iron liner removed, and the remaining slag and lead bullion tapped into a conical slag-pot. The smelting test is now replaced by a cupelling test which becomes sufficiently heated in half an hour to permit melting down lead which is charged from the back through an opening 6 in. square. When filled with lead and brought to cupelling temperature, the blast, furnished by a No. 3 Roots blower, is started and cupelling begun. When finished, the test is lowered onto a carriage, drawn from the furnace, and the gold-silver bullion broken, transferred to a Steel-Harvey oil-burning tilting crucible furnace, remelted, and cast into bars 0.975 fine, weighing about 2500 oz. The yield in precious metal is from 98 to 99.5 per cent.; the slag formed averages Au 1.73 and Ag 12.45 oz. per ton, and Pb 4.32 per cent.; the litharge-assays show Au 16.72 and Ag 147.59 oz. per ton. The cost of treatment is $0.043 per fine ounce. Two melts are carried on a month, each lasting 3–4 days.

Cupellation at the Homestake Mill.—The working of the zinc precipitate of the Homestake gold mills is discussed by Clark and Starwood (*Bull. Inst. Min. Met.*, 1913) in their extensive paper upon the treatment of Homestake ore. The precipitate is mixed with fluxes, litharge and coke, dried and briquetted; the briquettes are smelted on a bath of lead in an English cupelling furnace test (4 ft. 1 in. by 3 ft. 6 in.) for lead bullion to be cupelled, and for matte and slag; matte, slag, litharge, and cupel-bottom are smelted with pyrite and fluxes in a water-jacket blast-furnace (20 in. in diameter at the level of the three tuyères) for lead bullion, matte, and waste slag; the matte is sold.

Electroposition

For the symposium of the American Electrochemical Society upon this subject, F. C. Mathers (*Trans. Am. Electrochem. Soc.*, 1913, XXIII, 153; *Met. Chem. Eng.*, 1913, XI, 285, *Metall u. Erz*, 1913, X, 568) prepared a paper of 38 pages dealing with the electroplating of lead.

A process of electrolytically coating iron and steel with lead has been patented by Sherard Cowper-Coles (*Metal Industry*, 1912, IV, 308).

Another patent of similar purport is that of S. Edwards (U. S. Patent No. 1063248 June 3, 1913).

Electrolytic Plant at Trail, B. C.—This Betts electrolytic refinery of the Consolidated Mining and Smelting Co. is described by J. F. Miller (*Jour. Can. Min. Inst.*, 1913; *Met. Chem. Eng.*, 1913, XI, 463; *Min. Eng. World*, 1913, XXXIX, 57). The lead bullion containing Pb 97, Ag, Au, Sb, As, Cu, Zn, etc., 3 per cent. is cast into anodes weighing 400 lb. The 240 corroding vats with a daily capacity of 65 tons pure lead, are 30 in. by 7 ft. 4 in. and 44 in. deep. A vat is made of 4-in. fir, holds 20 anodes, spaced 4 1/8 in. centers. The cathodes weighing 162 lb. are cast sheets of lead; the electrolyte contains 12 per cent. H_2SiF_6 and 6 per cent. Pb SiF_6 which is circulated down cascades at the rate of 35 cu. ft. per hour. Cathodes weighing 200 lb. are replaced every five days, anodes every ten days furnishing 15 per cent. scrap which is remelted in a 50-ton kettle. The anode mud is washed, dried, melted and cast into doré bars to be parted with sulphuric acid. The plant is arranged for the recovery of the antimony by the McNab process (Min. Ind., 1909, XVIII, 504) but this is not in operation. The refined lead contains Zn 0.0005, Ag 0.0013, Cu 0.00075, Fe 0.00075, Sn 0.0001, Sb 0.0028, Pb 99,9938 per cent.

Electrolysis of Argentiferous Lead Ores.—A process of this character has been patented (U. S. Patent No. 1,056,383, March 18, 1913) by T. G. Timby.

Electrodeposition. Influence of Colloids.—The influence of colloids upon the smoothness of cathode lead has been studied by Freundlich and Fische (*Zeits. f. Electrochemie*, 1912, XVIII, 858, *Jour. Inst. Metals*, 1912, VIII, 346). It appears that the colloid is absorbed by the metal, and retards the velocity of crystallization, it thus increases the density and compactness of the deposit. The effect of colloids upon the deposition of lead and zinc has also been studied by R. Marc (*Zeits. f. Electrochemie*, 1913, June 1, 431).

LITHIA

By Victor Ziegler

Lithia is of very minor importance, its uses being so few and of such a nature as not to afford an active market. Formerly lithium carbonate was the main product, and this was used in the manufacture of artificial mineral waters and for other medicinal purposes. The product was chiefly prized in cases of rheumatism. A small amount is also used in fireworks and some lithium bromide is used in photography and medicine. The chief use of lithia at present is in the form of lithium hydrate in electric storage batteries. Nothing appears to be known of the exact action of the lithium hydrate beyond the fact that its presence prolongs the life of the battery.

Lithia in small traces is present in almost all rocks but in more characteristic of soda rich acidic igneous rocks and especially pegmatites. The chief sources of lithia are the minerals lepidolite, spodumene, lithiophylite, triphylite, and amblygonite. Lepidolite, the alumino-silicate of lithia, soda and potash, is also known as lithia mica, and lithionite. Its lithia content varies up to 4.2 per cent. It occurs in micaceous aggregates which vary in color from colorless into pink, yellow, green and brown but commonly a shade of lavender or lilac. Caesium and rubidium are frequently found in such lepidolite. It usually occurs in irregular shoots which are often of great size. Before 1886, Saxony and Bohemia were the chief producers of lepidolite, but in this year the amblygomite deposits of Montebras, in central France, were discovered and these soon became the chief producers in Europe. About 1900 the pegmatites of San Diego Co., California, attracted attention and for several years furnished several hundred tons of lepidolite annually, which were shipped to Europe for treatment. At present no lepidolite is used for lithia extraction. The Black Hills of South Dakota contain several pegmatites rich in lepidolite, while it is also prominent in similar pegmatites in Maine, Massachusetts and Connecticut.

Lithiophylite and triphylite are phosphates of iron, manganese and lithium which are of a green, brown or brownish-black color and a vitreous to resinous luster. They usually occur as disseminated nodules in pegmatites and are frequently associated with tin and niobium minerals such as cassiterite and columbite as well as wolframite, beryl, and uranium minerals. They have been found in the pegmatites of Maine, Massachussetts, Connecticut and North Carolina, but South Dakota seems to have been the only producing district. The total production was about

100 tons. All was exported. The lithia content of some lithiophylite is over 9 per cent.

Spodumene is an alumino-silicate of lithia carrying as much as 7 or 8 per cent. lithia. Its occurrence is quite similar to the other lithia minerals. Spodumene first attracted attention in 1900 as a source of lithia, and on account of its great abundance in the pegmatites of the Black Hills quickly became the chief source of lithia. It is known in a number of New England and North Carolina pegmatites but nowhere does it appear to occur in as great abundance or in as huge crystals as in the Black Hills of South Dakota. In the Etta mine near Keystone, where the crystals are best exposed, they frequently attain a diameter of 3 to 4 ft. and a length of 30 ft. The largest "log" so far found was 42 ft. long and 5 ft. 4 in. in diameter. This one log alone yielded 90 tons of spodumene. The crystals are not definitely oriented, but lie like a huge pile of logs penetrating the pegmatite in all directions. In a similar way, spodumene occurs in a number of other pegmatites near Keystone and in several near Custer. No spodumene is mined at present. The total production of the Black Hills to date is about 1400 tons.

At the present time, amblygonite furnishes all the lithia produced, by far the greater proportion coming from the Black Hills. This mineral is a phosphate of lithia and alumina and because it yields to cheaper treatment and gives more valuable by-products, makes the treatment of the other lithia minerals unprofitable. For some time pegmatites near Montebras, France, yielded amblygonite, but these deposits seem to be practically exhausted. A few hundred tons were produced in California in San Diego Co., near Pala, but there has been no production here for a number of years. Amblygonite was also discovered in the San Finx tin mine in Spain, and in northern Australia. The latter district produced 45 tons in 1906, but nothing since as far as known.

The Black Hills deposits are actively worked at present, the chief producing mines being the Peerless and the Hugo near Keystone. The amblygonite occurs in nodules, often of great size, but restricted in occurrence to shoots and pockets in the pegmatites. Individual nodules up to 1000 lb. in weight are common. One shoot of solid amblygonite exposed in the Hugo mine measured $15 \times 22 \times 40$ ft. The deposits are worked by open-cut methods. The total production for 1913 was in the neighborhood of 500 tons, while the total production of the Black Hills deposits up to 1914 is about 3000 tons. The amblygonite is shipped to Newark, N. J., where it is treated by the Standard Essence Co.

A detailed and illustrated description of the South Dakota deposits is given in "The Lithia Deposits of the Black Hills," *Eng. Min. Jour.*, Dec. 6, 1913.

MAGNESITE

By Edward K. Judd

Small deposits of magnesite, having only a mineralogic interest, are known in North Carolina, Pennsylvania, Maryland, and Massachusetts; others of potential importance have been discovered in Arizona, Nevada, and Western Texas; but the only commercial occurrences of the mineral, from which the entire production of the United States is derived, are in California, at scattered localities along the Coast Ranges and the western slopes of the Sierras.

STATISTICS OF MAGNESITE IN THE UNITED STATES.
(Tons of 2000 lb.)

Year.	Production. (a)		Imports.		Total	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1900	2,252	$19,333	28,821	(c)$216,158	31,073	$235,491
1901	4,726	43,057	33,461	(c) 250,958	38,187	294,015
1902	2,830	20,655	49,786	373,928	52,616	394,583
1903	1,361	20,515	54,776	461,399	56,137	481,914
1904	2,850	9,298	38,704	286,828	41,554	296,126
1905	3,933	16,221	74,374	638,619	78,307	654,840
1906	4,032	40,320	90,396	863,492	94,428	903,812
1907	6,405	57,720	99,008	875,359	105,413	933,079
1908	8,967	52,342	84,494	736,763	93,461	789,105
1909	7,942	62,588	114,292	985,019	122,234	1,047,607
1910	8,000	59,780	170,327	1,542,800	178,327	1,602,580
1911	9,900	67,430	122,420	1,114 520	144,449	1,253,297
1912	11,000	110,000	125,481	1,266,375	149,657	1,479,665
1913	.....	.....	167,933	1,669,300	.....	.....

(c) Estimated.

Roughly, 95 per cent. of the magnesite consumed in the United States is imported, mainly from Hungary and Greece, and is used, mostly as a refractory, along the Atlantic coast. The California output is consumed along the Pacific coast, mainly in the manufacture of sulphite liquor at the paper-pulp mills of Oregon and northern California. The domestic production is practically debarred from the Eastern market by a freight rate of about $10 per ton, against a rate of not over $2 paid for ocean freight on the European imports. Chemically, the California output is as desirable, for most purpose, as the best imported magnesite, and the Western producers entertain hopes that the opening of the Panama canal may permit them to compete for the Eastern trade. The expanding use of magnesite as a lining for copper converters, the leading copper smelters being situated in the West, may further encourage the California operators to develop their deposits so as to yield a larger and particularly a more dependable supply.

IMPORTS OF MAGNESITE INTO THE UNITED STATES.
(Fiscal year ending June 30.)

	1911.		1912.		1913.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Magnesia:						
Calcined, medical	91,029	$13,694	101,106	$16,326	72,579	$12,592
Carbonate, medical	50,490	2,867	60,904	2,727	77,190	3,811
Sulphate	5,950,861	22,559	10,703,209	41,739	9,345,099	35,739
Magnesite:						
Calcined, not purified	244,149,581	1,109,770	241,503,372	1,265,339	33,654,260	111,276
Crude	25,948,977	76,097	35,810,752	104,326	345,322,155	1,731,443

California.—The latest information as to recent developments at the magnesite localities is found in a report by H. S. Gale,[1] supplementing an earlier report by F. L. Hess.[2] The following data are taken from the later report; hence for complete information reference should also be made to the earlier.

Sonoma County.—On the east fork of Austin Creek, 8 1/2 miles north of Cazadero, two groups of claims have been located along a brecciated zone in serpentine containing thin stringers of magnesite, as well as a few veins ranging from 5 to 12 ft. thick. The veins are sharply faulted, and seem otherwise to lack continuity and regularity of thickness. Analysis of a sample across a 5-ft. vein cut by a tunnel is given in column I in the following table.

On Gilliam Creek, considerable work has been done by the Western Carbonic Acid Gas Co., of Agnew, Cal., but very little magnesite has ever been shipped. The veins are irregular and the product is too high in silica to be useful as a refractory. Two carloads of magnesite collected on the surface of the Eckert ranch, 2 miles east of Cloverdale, are reported to have been shipped in 1912; no underground development has been made.

Santa Clara County.—Extensive deposits have been developed at Red Mountain, in the southeast corner of the county, and 32 miles, over a good road, from Livermore. Within recent years, an important output of magnesite has been derived from this locality, having been calcined on the premises, but operations are now conducted on a small scale, the product being shipped to San Francisco in the raw state for the manufacture of a waterproofing paint. The magnesite occurs in irregularly situated veins in serpentine, reaching widths as great as 30 ft. An analysis of an average specimen of good material is given in column II in the following table.

[1] U. S. Geol. Surv., *Bulletin* No. 540, pp. 483–520.
[2] U. S. Geol. Surv., *Bulletin* No. 355.

Placer County.—Two occurrences are noted about midway between Damascus and Iowa Hill, and 12 miles from Colfax. In both, the magnesite veins are narrow and discontinuous, while difficulty of access to the deposits renders them of still more dubious commercial value.

San Benito County.—A large area of decomposed serpentine containing stringers of magnesite has been explored at the headwaters of Larious creek, 2 1/2 miles west of the New Idria quicksilver mines, and 40 miles from Mendota, the nearest railroad point. The main deposit is in the form of a blanket covering about 2.6 acres, but of relatively shallow depth. Other veins in the localities contain a more impure magnesite. Analysis of a composite sample from 12 points in the main deposit is given in column III in the table.

Tulare County.—The deposits 4 miles northeast of Porterville, formerly worked on a large scale by the Willamette Pulp and Paper Co., are now abandoned, all the more easily recovered magnesite having been extracted.

A deposit on the south fork of Tule River, 10 miles east of Porterville, has been operated for several years by the Tulare Mining Co., a railroad spur 2 miles long having been extended to the property. The principal deposit is a lenticular vein which has been followed underground for 1400 ft. All the product is calcined on the premises.

Kern County.—A recently discovered deposit near Bissell, on the Santa Fé Railway, 11 miles east of Mojave, has been sufficiently explored to indicate that the magnesite is undoubtedly of sedimentary origin, being unique among the California deposits for that reason. It occurs in beds, lenticular in form, and much distorted, interstratified with clays. Analysis of a sample of the best material at this locality is given in column IV in the table. This magnesite showed the unusual characteristic of disintegrating on exposure to the atmosphere.

Riverside County.—The deposit near Winchester, which has been operated continuously since 1908 by the California Magnesite Co., is now the largest producer in the State, having the advantages of an excellent mining site and proximity to market. The entire output is either made into cement, or is sintered at the mine, for further manufacture at Los Angeles. The deposit consists of a mass of magnesite veins disseminated through a mass of decomposed serpentine; on mining, the lumps of magnesite are readily separated from the rock, constituting about one-tenth of the material excavated. The principal working is an open cut 75 ft. in greatest width, 250 ft. long, and 60 ft. deep. In the bottom of the cut the proportion of magnesite appears to be no smaller than in the rock already excavated. Analysis of a composite sample from 30 places within this cut is given in column V of the following table.

COMPOSITION OF CALIFORNIA MAGNESITES.[1]

	I.	II.	III.	IV.	V.
SiO_2	3.66	0.73	0.81	4.75	6.17
Al_2O_3	0.75	0.14	0.00	0.76	0.80
Fe_2O_3	0.44	0.21	0.52		
CaO	0.20	0.40	1.04	Trace.	Trace.
MgO	44.90	46.61	46.67	44.20	43.80
CO_2	49.20	51.52	50.60	47.32	45.02
Undetermined	0.85	0.39	0.36	2.97	4.14
Total	100.00	100.00	100.00	100.00	100.00

[1] Quoted by H. S. Gale, U. S. Geol. Surv., *Bull.* 540. I. East Fork Austin Creek, Sonoma County II. Red Mountain, Santa Clara County. III. Larious Creek, San Benito County. IV. Bissell, Kern County. V. Winchester, Riverside County.

Nevada.—A discovery of magnesite has been reported from Lone mountain, near the south end of Big Smoky Valley, southwest of Tonopah. Samples indicate that the mineral is of good grade, but no information is at hand concerning the character of the deposits, nor their exact location.

THE PRINCIPAL SUPPLIES OF MAGNESITE.
(In metric tons.)

Year.	Austria-Hungary. (a)		Greece.		India. (d)	United States. (d)
	Crude	Calcined	Crude	Calcined		
1901	.....	40,236	20,348	.....	(e)	4,286
1902	.....	53,467	23,020	.....	3,597	2,567
1903	.....	69,058	28,415	.....	838	1,234
1904	.....	53,781	9,133	.....	1,193	2,585
1905	.....	92,359	37,063	.....	2,645	3,568
1906	.....	87,765	40,584	.....	1,861	7,093
1907	452	113,695	55,816	.....	188	6,858 (f)
1908	212	87,049	63,079	.....	7,655	5,994 (f)
1909	1,027	125,666	56,797	16,609	199	8,588 (f)
1910	341	182,911	18,073	19,982	5,264	11,291 (f)
1911	77	182,911	86,956	27,530	3,546	8,505 (f)
1912	.....	171,196	106,338	33,848	15,626	9,534 (f)
1913	.....	200,947	.....	.....	.....	.....

(a) Exports. (d) Crude magnesite. (e) Not reported. (f) U. S. Geol. Surv.

Newly Discovered Deposits of the World.—Two discoveries of magnesite deposits attracted attention in 1913: in Asia Minor and South Australia.

In Asia Minor, deposits were discovered north of the station of Eskechehir on the Bagdad railway. The quantity available is about 300,000 tons without much need of development. The beds vary from 3 to 15 ft. thick. Both in physical properties and purity this magnesite compares favorably with other deposits. A number of assays give the purity at 99 per cent. The work done so far consists of shafts and inclines.

Deposits at Tumby Bay, South Australia, have been investigated by the government geologist, who reports that the magnesite occurs in veins or greatly elongated lenses which appear to be vertical. A large number of these veins occur irregularly spaced along a zone over 1300 ft.

in length and 100 ft. in width. The maximum thickness of the veins is between 4 and 5 ft. and a few of them appear to extend continuously for a length of 40 ft. At a few points there are outcrops of what seem to be short cross-veins connecting the longer ones. Closely associated with the magnesite are vein-like aggregates of quartz, hematite, and some impure siliceous replacement product. These aggregates are in some places revealed only in the trenches, while in other places they form prominent outcrops. Samples showed from 41.83 to 46.23 per cent. magnesia, and from 46.86 to 50.99 per cent. carbon dioxide. Impurities are variable: It is estimated that the magnesite of this locality can be mined, sorted, and delivered at Adelaide for £1 5s. per ton. The total tonnage in the deposits is problematical.

ANALYSES OF MAGNESITE.

	SiO_2 Per cent.	Al_2O_3 and Fe_2O_3 Per cent.	CaO Per cent.	CO_2 Per cent.	MgO Per cent.	$MgCO_3$ Per cent.
Greece	1 to 2	1.75 to 3.20	1.10 to 3.20	.....	.....	92 to 98
Elba	8.5	Trace.	3.50	.....	41	.....
Transvaal	2.3	0.8	.....	49.8	45.3	.....
New South Wales	0.42	0.54	*Nil.*	.....	.....	99.01
New Caledonia	0.8	0.8	3.3	51.5	42.4	.....
Silesia	5.6	0.85	0.12	.....	.....	93.0
Hungary	0.75	3.50	1.2	50	45	.....
Lower California	Trace.	0.21	0.43	.....	.....	99.36
Atlin, B. C.	45.7	5.10	.....	27	22	.....
Margarita, Venezuela	0.2	0.15	0.56	51.6	46.93	98.04
Magnesium carbonate	.....	.....	.....	52.4	47.6	.....

Uses of Magnesite[1]

Refractory Products.—The use of magnesite for refractory products constitutes its most important application in the industries. Made into refractory bricks it is used as linings for basic steel furnaces. In "dead burnt" calcined form as originally burned, or as brick, the magnesia is used as a refractory lining for open-hearth furnaces and converters in the steel industry, for rotary kiln linings in Portland cement manufacture, for furnace hearths, crucibles, cupels, etc.

It is commonly believed that the most refractory magnesite is the "dead burnt" product derived from magnesite containing little or no lime, silica, oxide of iron, or alumina. The presence of lime in magnesite bricks used at high temperatures is said to cause them to disintegrate more readily, and in basic steel furnaces the lime is believed to cause the phosphorus to pass into the hearth instead of the slag, the hearth thereby becoming rotten. Silica, oxide of iron, and alumina are supposed to be objectionable because they have a tendency to lower the fusing point.

[1] H. S. Gale, U. S. Geol. Surv., *Bull.* 540, p. 487.

On the other hand, analyses of the imported magnesite, which constitutes by far the greater part of the product consumed in this country and is assumed to represent a standard of desirable composition for practical purposes in the metallurgical industry, generally show 3 to 4 per cent. of silica, 6 to 8 per cent. of iron, and 4 per cent. of lime. The percentage of almuina usually found is said to be so small that it need not be considered. Apparently there is some divergence of opinion as to the most desirable composition of magnesites to be adopted for metallurgical refractory uses.

Paper Manufacturing.—The availability of magnesite in the deposits in California has led to the considerable use of magnesium bisulphite in the manufacture of wood-pulp paper in that state.

In the sulphite process of paper making the wood (mostly coniferous wood) is boiled with a disintegrating agent until it breaks down into a mass of pulp, which is afterward rolled into paper. The disintegrating agent is sulphurous acid or common bisulphite of calcium or magnesium. Magnesium bisulphite is more stable than calcium bisulphite, it dissolves the non-cellulose matter more completely, and it has the additional advantage that the residues left in the stock are not afterward injurious to sizing agents. Sodium bisulphite gives a better product than either the magnesium or the calcium salt, and strong liquors can be made from it, but it is too expensive for general use.

It is estimated that the greater part of the California magnesite is now used in the manufacture of paper by this process. The deposits near Porterville, which have been for years the largest producers, have been worked primarily for this purpose.

Manufacture of Carbon Dioxide.—The manufacture of carbon dioxide from raw magnesite consists in the decomposition of the magnesium carbonate by ordinary calcination, the carbon dioxide being recovered, purified, and, compressed, and the residual magnesia being also available as a by-product. It is understood that the use of magnesite for this purpose has now been largely or wholly abandoned on the Pacific coast, as carbon dioxide can be produced more cheaply as a by-product in other processes; for instance, it is now made as one of the products of fermentation in a distillery.

Cement.—The use of magnesite for the manufacture of oxychloride or Sorel cement is apparently a promising field. This product consists of a mixture of finely ground calcined magnesite with magnesium chloride, which, when it has been wet, sets in an exceedingly strong, somewhat elastic cement. The material for this cement is marketed under many trade names, being especially referred to as a sanitary flooring. For flooring, wainscoting, and similar uses the cement is mixed with wood

flour, sawdust, cork dust, or some similar material. When well and successfully laid, magnesite cement has some important advantages over other cements for this purpose. It produces a smooth, even floor, which may be laid in thin sheets over large surfaces without cracking. It takes colors readily, and is susceptible of a good polish with oiling or waxing. It is laid in a plastic state on wood or concrete. Its surface seems to have a resilience not apparent in ordinary cement, and it does not pulverize or grind to dust. This cement is said to have been very extensively used abroad for flooring and to be gradually coming into wider use in this country. It is also reported to have found a use in the manufacture of artificial marble and fine tiles.

Other Uses.—Magnesite in both crude and calcined form finds numerous miscellaneous applications, among which may be mentioned its use as heat-insulating pipe covering. For this purpose it is commonly mixed with asbestos fiber, and the artificial magnesia alba levis seems to be best. Magnesite is said to be used as an anti-acid in the manufacture of dynamite, as an adulterant in paint, and as a preventive of scale in boilers in which sulphurous waters are used. It has been tried with some success as a binder for briquetting coal, where it has the disadvantage common to all inorganic binding materials, namely, that they increase the ash without adding to the combustible portion of the fuel.

The use of magnesite in a fireproof or fire-retarding paint is also reported to be increasing. Wood and burlap coated with a paint made of magnesite are said to resist fire so that, while they can be burned by the direct application of heat and flame, the fire will not spread beyond the area actually exposed to the flame.

Refined magnesia salts are used for medicinal and toilet purposes. The commercial preparation known as magnesia alba is a basic carbonate of slightly varying composition, according to the conditions of production. It is usually prepared by precipitation of either the commercial sulphate or chloride of magnesium with sodium carbonate. Epsom salts (magnesium sulphate) is derived from the deposits at Stassfurt, Germany, and is imported on a considerable scale but is also manufactured by the chemical treatment of magnesite. A considerable quantity of magnesia quoted as "medical, calcined" is imported annually, probably representing a purified product for medicinal or other uses.

MANGANESE

By James Aston

While manganese exists in nature as part of very many minerals, and is a relatively widespread element, the limited demand and the abundant supply to draw upon, means a market for ores only of the better quality. Manganiferous iron ores are mined in large quantities in the Lake Superior district, and in lesser amount in Colorado, but the product of the smelting operation is a rather high manganese pig iron (1 to 4 per cent. Mn), and the above ores, therefore, should not be regarded as a source of manganese or manganese alloys. The straight manganese ores, on the other hand, although deposits occur in many parts of the United States, have a very limited and relatively unimportant production. Virginia produces practically all of the few thousand tons of annual output. The chief domestic source of ferro-manganese, in which form manganese has its principal commercial outlet, is the franklinite ore of New Jersey. This material is first treated for the recovery of zinc, and the residue, containing about 12 per cent. manganese and 40 per cent. iron, is smelted to spiegeleisen. The chief production of ferro-manganese in this country is, however, from imported ores.

The total ore production of the United States is shown in the following table:

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES. (a)
(Tons of 2240 lb.)

Year.	Manganese Ores.				Manganiferous Iron Ores.				Man. Zinc Ores.	Total Production.	
	California.	Georgia.	Virginia.	Other States.	Arkansas.	Colorado.	Lake Superior.	Va. & N. C.	New Jersey.	Long Tons.	Value.
1900.	131	3,447	7,881	312	*Nil.*	43,393	75,360	*Nil.*	87,110	217,546	1,172,447
1901.	610	4,074	4,275	3,036	*Nil.*	62,385	512,084	20	52,311	638,795	1,644,117
1902.	846	3,500	3,041	90	*Nil.*	13,275	884,939	3,000	65,246	973,937	2,145,783
1903.	16	500	1,801	508	*Nil.*	14,856	566,835	2,802	73,264	660,582	1,670,349
1904.	60	*Nil.*	3,054	32	600	17,074	365,572	*Nil.*	68,189	454,581	789,132
1905.	1	150	3,947	(e) 20	3,321	45,837	720,090	*Nil.*	90,289	863,663	1,681,472
1906.	1	.....	6,028	892	8,900	32,400	1,000,008	*Nil.*	93,461	1,141,681	(e)3,403,993
1907.	100	*Nil.*	(d)4,604	900	4,133	(d) 99,711	(d) 314,316	*Nil.*	93,413	517,177	1,510,156
1908.	321	*Nil.*	(e)6,144	200	(d) 4,066	(d) 51,524	(d) 467,140	274	110,225	633,650	1,280,989
1909.	3	*Nil.*	1,334	*Nil.*	(d) 3,325	(d) 65,024	(d) 775,035	305	141,264	986,481	2,209,461
1910.	(f)	*Nil.*	2,059	199	(d) 5,030	(d) 55,770	(d) 558,634	301	137,173	759,166	1,938,429
1911.	(f)	*Nil.*	(g)2,457	*Nil.*	(d) 2,177	(d) 41,753	477,920	507	109,296	634,110	1,386,464
1912.	(f)	*Nil.*	(g)1,664	*Nil.*	(d) 1,332	(d) 48,618	816,984	1,567	104,670	974,835	1,982,000
1913.	(f)	*Nil.*	(g)4,048	*Nil.*	(d) 9,650	(d) 49,753	(d) 612,743	(f)	(d) 102,239	778,433	.....

(a) Statistics of 1900–1906 are by the U. S. Geological Survey. (b) Includes 1300 tons of manganiferous iron ore from Vermont. (c) As reported by Virginia Geological Survey. (d) As reported by U. S. Geological Survey. (e) Estimated. (f) Figures not available. (g) Includes Tennessee and California.

Domestic production of ferro-manganese, as reported by the American Iron and Steel Institute, was 119,496 long tons, a decrease of 5882 tons, or 4.6 per cent. compared with 1912. For spiegeleisen the tonnage was 110,338, being an increase of 13,992, or 14.5 per cent., over 1912. The total for the year 1913 is therefore 229,834 tons, an increase for the year of 3.7 per cent.

UNITED STATES PRODUCTION OF IRON-MANGANESE ALLOYS.
(Tons of 2240 lb.)

	1910.	1911.	1912.	1913.
Ferromanganese	71,376	74,482	125,378	119,496
Spiegeleisen	153,055	110,235	96,346	110,338
Totals	224,431	184,717	221,724	229,834

Importation of ores is about one-fourth of domestic production, including in the latter the manganiferous iron ores; while the imports of manganese alloys equals the home production. The lower grade of the United States ores is reflected in the fact that imports of spiegeleisen with 25 per cent. Mn, are usually less than one-fourth of the domestic production, while the imports of ferro-manganese, with 80 per cent. Mn, in general equal or exceed the domestic yield. Saving of transportation per unit of manganese, is an important factor in the relatively larger importation of the ferro-manganese. Import figures are as follows:

UNITED STATES IMPORTS OF MANGANESE ORES AND ALLOYS.
(Tons of 2240 lb.)

	Ores.	Alloys.		
		Ferro-manganese.	Spiegel-eisen.	Total.
1903	146,056	41,519	122,015	166,534
1904	108,519	21,813	4,623	26,436
1905	257,033	52,841	55,457	108,298
1906	221,260	84,359	103,268	187,627
1907	209,021	87,400	48,994	136,394
1908	178,203	44,624	4,579	49,203
1909	212,765	88,934	16,921	105,855
1910	242,348	114,228	25,383	139,611
1911	176,852	80,263	20,970	101,233
1912	300,661	99,137	1,015	100,152
1913	345,090	128,070	77	128,147

India, Russia, and Brazil[1] have large deposits of good-grade manganese ore, favorable to transportation, and these countries, with the United States, are the principal producers. For many years Russia has had the leading position, the high-grade deposits of pyrolusite and other oxides of the Kvirila basin in the Caucasus, being the center of production, especially for export. Recently, because of high freight rates, strikes, and the Balkan trouble, the production of India has been running a close race

[1] *Min. Sci. Pr.*, May 10, 1913.

for the premier position. In Brazil, in the state of Minas Geraes, are large deposits of good quality, which contribute about one-tenth of the total output. All of the above ores meet the trade requirements of phosphorus lower than 0.20 per cent., and silica less than 8 per cent. The ore produced in the United States is lower in manganese content than that of the three foreign countries named above. The worlds production for eleven months of 1913 is just above 2,000,000 tons, slightly over half being from the Russian Caucasus.

While the use of manganese alloys is increasing, the ores as yet present no great attraction to the prospector, since their exploitation is uncertain of commercial profit, unless the ores are of high purity and favorably situated for mining and transportation.

The world's production of manganese ores, so far as figures are available, is as follows:

WORLD'S PRODUCTION OF MANGANESE ORE. (a)
(In metric tons.)

Year.	Austria-Hungary.	Belgium.	Bosnia (b)	Brazil (d)	Canada.	Chile. (d)	Colombia.	Cuba.	France	Germany.	Greece.	India.
1900	14,550	10,820	7,939	108,244	34	25,715	8,748	21,973	28,992	59,204	8,050	129,865
1901	12,077	8,510	6,346	100,414	447	18,480	95	25,586	22,304	56,691	14,166	122,831
1902	12,883	14,440	5,760	157,295	175	12,990	Nil.	40,048	12,536	49,812	14,960	160,311
1903	11,489	6,100	4,537	161,926	135	17,110	(c)	21,070	1,583	47,994	9,340	174,563
1904	15,460	485	1,114	208,260	123	2,324	(c)	33,152	11,254	52,886	8,549	152,601
1905	23,732	Nil.	4,129	224,377	22	1,323	(c)	(d) 8,096	6,751	51,463	8,171	250,788
1906	20,577	120	7,651	121,331	84	35	(c)	(d) 13,997	11,189	52,485	(d) 9,200	579,231
1907	24,954	2,100	7,000	236,778	1	(c)	(c)	30,486	18,200	74,683	10,000	916,770
1908	27,257	7,130	6,000	166,122	Nil.	1	(c)	1,492	15,865	67,692	10,750	685,135
1909	29,966	6,270	5,000	240,774	Nil.	(c)	(c)	2,976	9,378	77,177	5,374	652,953
1910	28,964	Nil.	4,000	253,953	Nil.	(c)	(c)	(c)	7,925	80,559	41	813,761
1911	15,954	Nil.	3,600	213,000	5	(c)	(c)	.....	6,036	87,297	(c) 733	670,290
1912	12,471	Nil.	4,650	154,870	68	(c)	(c)	.....	5,576	92,474	.....	637,444
1913	16,540	Nil.[1]	.....	(c)	(c)	(c)	(c)	(c)	(c)	(c)	.....(11	810,000
												months

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	Spain.	Sweden.	United Kingdom	United States. (e)
1900..	6,014	15,831	166	1,971	77	802,236	112,897	2,651	1,384	221,714
1901..	2,181	16,270	208	904	221	522,395	60,325	2,271	1,673	649,016
1902..	2,477	10,844	Nil.	(c)	4,674	536,519	46,069	2,850	1,299	989,519
1903..	1,930	5,616	71	30	1,341	414,334	26,194	2,244	831	671,151
1904..	2,836	4,324	199	(c)	843	430,090	18,732	2,297	8,880	461,854
1905..	5,384	14,017	55	(c)	1,541	508,635	26,020	1,992	14,582	877,482
1906..	3,060	54,339	16	22	1,131	1,015,686	62,822	2,680	23,126	1,141,681
1907..	3,654	20,589	26	1,374	1,134	995,282	41,504	4,334	16,356	517,177
1908..	2,750	11,130	Nil.	.....	1,403	362,303	16,945	4,616	6,409	633,650
1909..	4,700	8,708	6	.....	613	574,938	7,827	5,212	2,812	986,477
1910..	4,200	11,120	5	.....	805	(d)668,050	8,607	5,752	5,554	784,464
1911..	3,515	9,769	1	6	1,000	(d)584,000	5,607	5,377	5,057	644,288
1912 .	2,641	8,362	.....	6	313	(d)766,000	19,936	5,101	4,170	990,000
1913..	(c)	(c)	(c)	(c)	27	1,310,000	(g) 22,353	(c)	(c)	791,407

(a) From official statistics. (b) Includes Hersegovina. (c) Statistics not available. (d) Export returns. (e) Includes output of manganiferous iron ore. (f) Six months. (g) Exports for first 10 months.

During the year the United States Steel Corporation through the Carnegie Steel Co. has entered the market as a seller of 80 per cent. ferro-manganese,[1] after a withdrawal of several years' duration. The product is made at Pittsburgh, Birmingham, and South Chicago furnaces. The company expects to supply a good part of the demand in the Central West and South, and will probably take business in seaboard districts in competition with foreign material, if prices are satisfactory. Contracts will be made on a sliding scale for requirements, on a monthly settlement basis. This company manufactures about 80 per cent. of the ferro-manganese made in this country.

It is announced[2] that the American Manganese Manufacturing Co. is about to apply for a Pennsylvania charter to manufacture ferro-manganese. The company, with a present nominal capital to be later increased to twelve million dollars, is a merger of the Cuyuna Mille Lacs Iron Co., the Duluth Iron Co. and the Dunbar Furnace Co. including allied coal and coke interests. The two Duluth companies own manganiferous iron-ore deposits on the Cuyuna Range. Ferro-manganese will be produced from the above, together with imported ores, at the Dunbar Furnaces, which have been idle for a number of years.

During the latter part of 1913, the Carnegie Steel Co. price schedules for manganese ores for Pittsburgh or South Chicago deliveries were as follows: 48 per cent. or over in manganese, 25 cents per unit—46 to 49 per cent., 24 cents—43 to 46 per cent., 23 cents—40 to 43 per cent., 22 cents. The above for ores carrying not more than 8 per cent. silica and 0.20 per cent. phosphorus. Deductions to be 15 cents per ton for each 1 per cent. silica over 8 per cent., and 2 cents per unit of manganese for each 0.02 per cent. phosphorus over 0.20 per cent. Ores of less than 40 per cent., manganese, more than 12 per cent. silica, or over 0.225 per cent. phosphorus, are subject to buyers option of acceptance or refusal.

British quotations at United Kingdom ports for about the same period were as follows:

Indian or Brazilian ore	50 per cent.	20 cents to 20 1/2 cents per unit
	48 per cent.	19 cents to 18 1/2 cents per unit
	45 per cent.	18 1/2 cents to 19 cents per unit
Caucasian ore	50 per cent.	17 1/2 cents to 18 cents per unit
	48 per cent.	17 cents to 17 1/2 cents per unit

In keeping with the tone of the steel industry, the ferro-manganese market, as reflected by prices, started in strong, but ended very weak. In early January of 1913, the quotations at Baltimore for foreign material were $75 to $80 per ton, with sharp demand. Quiet to dull conditions resulted in falling prices and cutting by both English and German

[1] *Iron Age*, Dec. 25, 1913. [2] *Iron Age*, Apr. 23. 1914.

producers throughout the year. Subsequent quotations were $59 at midyear for prompt shipment, and $47 at the close. Freights to Pittsburgh $2.16.

A cut from $56 to $50 in October was in part due to the revision of the tariff. The schedules, old and new, are given below:—

	Old.	New.
Oxide of manganese	Free	Free
Ores of manganese	Free	Free
Ferro-manganese and Spiegel, per ton	$2.50	Free
Manganiferous iron ore, per ton	0.15 cents	Free

In December, manganese metal was quoted at 90 cents per pound, with a duty of 10 per cent.

At the close of the year, the Piedmont Manganese Corporation, of Lynchburg, Va., was thrown into receivership with a bonded debt of $665,000 in addition to the floating debt.

Foreign Countries

Russia.—The important deposits of manganese ores are in the Caucasus. The principal mines are at Tchiatouri, about 126 miles from the Black Sea ports of Batum and Poti. The exploitation began in 1878, but production was on a limited scale until 1885, when theTrans Caucasus Railway was constructed. The ore is in large part exported and this export movement has almost doubled in 3 years.[1] Shipments through the ports of Poti and Batum were 1,059,810 metric tons for 1913. Of this, 405,390 tons went to Germany, 242,960 to Great Britain, 179,276 to Belgium, and 135,390 tons to the United States. In 1913, the United States took seven times as much Caucasian manganese ore as in 1912. Exports exceeded production of the mines, by ahout 300,000 tons, and ore stocks were reduced to about 560,000 tons on January 1, 1914, as compared with 715,000 tons a year previous. Fifty per cent. of manganese ore was quoted during the first half of 1913 at 7 to 7 1/4 kopecks per pood ($1.09 to $1.13 per long ton or 2.2 cents per unit) at mines at Tchiatouri, and 19 to 20 kopecks per pood ($2.96 to $3.11 per long ton or 5.9 to 6.2 cents per unit) at port of Poti.

Exploitation will shortly begin at Mgdvimeni, a deposit belonging to the same Kvirila basin as exists at Tchiatouri. The whole basin occupies an area of 72 square miles. The Tchiatouri deposits contain an average of Mn 55 per cent., P_2O_5 0.15 to 0.20, SiO_2 1.69 to 6.67. The Mgdvimeni ore contains up to 60 per cent. of metallic manganese.

The sixteenth congress of Russian manganese producers (attended by 25 producers) voted it necessary to improve the shipping facilities at

[1] *Daily Consular and Trade Report.*

Poti and Batum.[1] It was also decided to assess a tax of one-half kopeck per pood (1/4 cent per 36.11 lb.) on all manganese exported after January 1, 1914, but to allow a rebate of one-half of this amount for the first 6 months of 1914 to those exporters who had already made contracts.

The manganese industry of the Russian Caucasus suffered a severe check because of the strike of the workmen which began in June, and was not settled until September.[2] The men returned to work after being granted shorter working hours, improved living conditions, and increased wages, in most branches of work from 20 to 25 per cent., and for piece workers from 75 to 80 per cent. It is thought that it will be a long time before the manganese industry recovers from the check. In recent years this industry has grown to be the important feature of the trade of Batum, but the higher freight rates from the Black Sea, coupled with the increased cost of production, will probably result in a lessened amount of business.

Production of the Nikopol district is estimated at 266,100 tons for the year, from three mines. The greater part is used by South Russian metallurgical works, and it is replacing in considerable measure the more distant Caucasian ore. A small proportion is shipped by rail to Germany, and by sea to England and the United States, the total amounting to about 55,000 tons.

India.—Production for the first 11 months reported as 810,000 tons. There has been considerable increase in export trade from all ports,[3] although proportionately the share of Bombay has fallen in the totals for India. In view of the congestion for shipping and export via Bombay, equalization of railway rates from the Central Provinces to Bombay and Calcutta has been advocated, to direct traffic to the latter port and meet the needs of the mining districts for enlarged shipping facilities.

Australia.—Is reported[4] to be developing large deposits of manganese and hematite ores. The owner is the Victorian Mines, Iron, and Steel Co., of London, which has spent $350,000 in proving the mines. It is stated that there are 40 million tons of high-grade manganese ore containing 88.6 per cent. of MnO_2, in addition to immense quantities of hematite ore. The deposits are near seaport, and large supplies of limestone are at hand, with good coking coal available at reasonable cost. It is estimated that ferro-manganese can be manufactured at the site and delivered in Great Britain at $22 per ton. The company proposes to build a railroad to the coast and eventually form a large company to manufacture steel.

[1] *Daily Consular and Trade Report*, Feb., 1914.
[2] *Daily Consular and Trade Report*, July 30; Sept. 16, 1913.
[3] *Daily Consular and Trade Report*, Oct. 9, 1913.
[4] *Iron Age*, July 31, 1913.

Philippines.—The Bureau of Science, Manila, states that manganese ore in considerable quantities exists in the Philippines. It seemed possible to develop the industry, but it was found that there is an export and wharfage charge on all ores. If the ore were shipped as ballast to Japan, this would not be serious; but if it were shipped to the west coast of the United States, the freight rate would wipe out all profits. It is recommended that a law repealing export dues be passed.

In General.—Manganese deposits of Central Uruguay will soon have an outlet through a 75-mile branch railway constructed by the government.

H. K. Scott[1] describes the manganese ore deposits in Bulgaria. The Bela deposit occurs near the shores of the Black Sea, and contains a large quantity of mineral with 35 per cent. of manganese in the dried ore. It would not be profitable to ship in the raw state, but this might be feasible after sintering or briquetting. Other outcrops of manganese of limited quantity are also described.

In Canada there are deposits of manganese ore in the eastern provinces of Nova Scotia and New Brunswick, but there was no mining in 1913, other than minor amounts connected with development work.

Exports from Spain for the first 10 months were 22,353 tons compared with 25,285 for the corresponding period of 1912.

Germany imported 680,371 metric tons of manganese ore in 1913, compared with 523,125 tons in 1912. Exports for the same periods, 7790 and 9388 tons. Domestic production was 92,474 metric tons in 1912.

Imports of Great Britain were 601,207 tons for 1913, against 387,738 tons for 1912.

France imported 258,929 metric tons of manganese ore in 1913, or 33,450 less than in 1912. Exports were 1705 tons, an increase of 567 tons.

Technology

Manganese has its most extensive use in the steel industry, where it is added in a small resultant quantity (about 1/2 to 1 per cent. remaining after treatment) to practically all Bessemer and open-hearth steel as deoxidizer, recarburizer, and neutralizer of sulphur. The addition agent is spiegeleisen, containing 10 to 40 per cent., but usually about 20 per cent. manganese; and ferro-manganese, with above 40 per cent. of this element, but with a usual standard of 80 per cent. manganese. There is also in less general use, silico-spiegel, with manganese about 17 to 22 per cent., and silicon 6 to 12 per cent.

[1] *Inst. Min. Met., Bull.* 103.

Besides this general use of the ferro-alloy, increasingly greater amounts are being used in manganese steels, where about 15 per cent. of manganese confers great hardness and toughness on the steel. The main outlets are for dies and shoes in stamp milling, crusher jaws and rolls, tube-mill liners, hard center construction in track crossings and frogs, rails for special service, such as in curves where wear is particularly severe, safe and vault material, steam shovel and dredge parts, and analogous products requiring resistance to excessive abrasion and wear, accompanied by shock.

The greatest drawback is the permanent hardness of the product; it is not softened sufficiently to be capable of machining by any heat treatment. Therefore its only uses are in such shapes as can be cast or rolled, and where any holes or finishing can be done by punching or grinding. Punches have been designed to give satisfactory holes in rails, but there is still much breakage.

Considerable progress has been made in the past year or two in the development of casting, rolling, and treatment methods to improve the quality and lower the cost of the product. The Illinois Steel Co. has installed at South Chicago, a large quenching tank, into which the rails are fed continuously after cambering. The rapid cooling brings out the maximum toughness of the product. There is still difficulty in rolling because of seaming and stratifying.

The production of rails in 1913 was 11,864 tons; this figure includes those with copper and nickel additions, as well as manganese, but the tonnage of the first two classes is small. Manganese steel rails sell for about $100 to $130 per ton, as compared with $28 for standard product. The production of manganese steel castings is estimated at 30,000 tons for the year, of which about 11,500 tons were used in special track work. This was some increase over 1912, but figures for accurate comparison are not available.

Manganese steel rails have been made for 5 years or more, but on a commercial scale only for the past 2 or 3 years. Specifications of the Manganese Steel Rail Co., give a composition of C 0.95 to 1.35, P not over 0.10, Mn 10.50 to 15.0, for all sections. All rails must be quenched in cold water within 20 seconds after the final pass. A 2-in. section of the finished rail must stand a 90-deg. cold bend of the head toward the base before fracture. Rails must also be subjected to suitable drop tests, varying with the section.

Manganese as a ferro-alloy and as metal is used to a considerable extent in non-ferrous lines as a deoxidizer, principally in brass and bronze, and as manganese bronze, an alloy of manganese and copper.

As the oxide, manganese is used as a depolarizer in the manufacture of

dry cells. Here the estimated annual consumption is 15,000 to 20,000 tons. Also as a coloring material in the glass industry, as a drier in paints and varnishes, and to a small degree as a flux in certain smelting operations, in chemical manufacture, and in medicinal and kindred uses.

The melting point of manganese of approximately 97.5 per cent. purity has been determined by the Bureau of Standards[1] as 1254 C.; this is possibly 20° below the temperature for strictly pure manganese.

United States patent 1078199 has been granted to Friedrich Heusler for a method of reduction of manganese from its ores by carbon after calcining a portion of the ore at high temperature. About fifty parts of the calcined material to one hundred of the raw ore are mixed with enough lime for a flux, and soot or oil, and heated in a graphite crucible to a high temperature. An increased yield of manganese is claimed. A charge of 100 per cent. of calcined ore, however, does not reduce readily.

Patents have been granted[2] to L. Goldmerstein covering an interesting application of manganese sesquifluoride in the Bessemer converter to rid the steel of phosphorus, hydrogen, and sulphur. The fluoride is introduced after the silicon is blown, and is injected with the blast, being preferably heated before adding. The impurities in the steel are eliminated as gases. Fluorides of nickel, manganese, copper, etc., are satisfactory, but that of manganese is most situable. Natural fluorides, as cryolite or fluospar, are too stable to be of service. At present, manganese sesquifluoride is not on the market, but a German firm is prepared to deliver it at New York at a cost, including duty, of about 13 cents per pound. The cost of treatment in such case is estimated as $1.66 per ton of steel, for a steel of initial 0.25 phosphorus reduced to 0.05. But 6 lb. of manganese are at the same time introduced into the metal, and the cost is offset by the possibilities of use of lower grades of pig iron in the Bessemer converter.

J. H. Hall describes[3] the foundry operations and heat treatment in the production of manganese steel castings. These have been made under license in the United States for 20 years. The product is made from Bessemer blown steel, to which is added ferro-manganese previously melted in crucible furnaces. The steel is very homogeneous and free from blow-holes, because of the powerful cleansing properties of the manganese; but shrinkage and contraction are excessive, and special precautions are needed in pouring the castings and making the molds. After cooling in the molds, the castings must be gradually heated to the proper temperature and quickly quenched in cold water, to obviate brittleness.

[1] *Reprint* 205.
[2] *Iron Age*, Jan. 22, 1914.
[3] *Iron Age*, Vol. 91.

BIBLIOGRAPHY

ARRIVAUT.—Researches Upon the Alloys of Manganese and of Silver. *Rev. de Met.*, Nov., 1913.

BURCHARD, EARNEST F.—Sources and Principal Uses of Manganese. *Min. Eng. World*, Jan. 11, 1913, p. 68.

HADFIELD.—Heating and Cooling Curves of Manganese Steel. *Jour. Iron and Steel Inst.*, Vol. II, 1913.

HADFIELD.—Manganese Steel Rails. *Bull. Am. Inst. Min. Engrs.*, Feb.,1914.

HAENIG.—Production and Uses of Manganese Alloys. *Elektrochem. Zeit.*, Vol. XIX.

HARDER, E. C.—Manganese, Its Production and Uses. *Bull.* 427, U. S. Geol. Surv.; *Min. Eng. World*, Dec. 14, 1912, p. 1082.

HILPERT AND HERMAN.—Thermo-Electric Properties of Some Irreversible Steels of Nickel and Manganese. *Zeit. Elektrochem*, Vol. XIX, 1913.

KRAUTH, O.—Die Mineralschatze des Kaukasus. *Technische Blätter*, Feb. 22, 1913, p. 57.

SCHEFFER, HR.—The Importance of Manganese and Manganese-Iron Ores in German Industry. *Glückauf*, Dec. 13, 1913.

SCHMIDT, ALBERT.—Die nordbayrischen Eisen und Manganvorkommen. *Berg and Hüttenmann. Rundschau*, Sept. 5, 1913, p. 293.

STADELER.—Influence of Manganese on the Strength of Mild Steel. *Zeit. anorg. Chem.*, Vol. LXXXI, 1913.

STONE,—Use of Manganese Steel for Special Purposes. *Iron Age*, Vol. XCI, 1913; *Min. Sci. Pr.*, Feb. 15, 1913, p. 280.

TABUGI.—Utilization of Highly Siliceous Iron and Manganese Minerals. *Chem. Ztg*, Vol. XXXVII, 1913; *Eng. Min. Jour.*, July 12, 1913, p. 64.

Iron and Manganese Ore in Victoria, Australia. *Iron and Coal Trade Rev.*, Vol. LXXXVI, 1913.

———L'Acier au Manganese. *Rev. Pratiq. d'Ind. Met.*, Jan., 1913, p. 7.

———. La Production du Manganese dans le Monde. *Rev. Pratiq. d'Ind. Met.*, Aug., 1913, p. 7.

———. Le Manganese dans l'Inde Britannique. *La Metallurgie*, Jan. 15, 1913, p. 40.

———. Les Paises Productores de Manganese. *Revista Minera*, Aug. 24, 1913, p. 413.

———. Manganese Ore Trade of the Caucasus. *Iron and Coal Trade Rev.*, June 27, 1913, p. 1039.

———. Russische Manganerz. *Technische Blätter*, Apr. 5, 1913, p. 105.

———. Some Manganese and Copper Developments in the Olympic Mountains, Washington. *Pacific Min. Jour.*, July, 1913, p. 1.

———. Specifications for Manganese Steel Rails. *Ry. Age Gaz.*, Aug. 15, 1913.

———. The Manufacture of Manganese Steel Castings. *Iron Trade Rev.*, June, 1913.

———. The World's Supply of Manganese Ores. *Iron Age*, June 12, 1913, p. 1432.

MICA

By Edward K. Judd

The total value of the mica produced in the United States in 1913,[1] as reported by the U. S. Geological Survey, was $436,060, an increase of $104,164 over 1912, and the largest output, in point of value, ever produced. The total comprised 1,700,677 lb. of roughly trimmed and cut mica, estimated to be worth $353,517, and 5322 short tons of scrap mica, valued at $82,543. The unit values of cut mica are subject to considerable doubt, but the returns indicate that the price during 1913, averaging 20.8 cents per pound, was lower by 12.6 cents than during 1912, and higher by 4.4 cents than in 1911. The output of sheet mica during 1913 was about double that of the previous year.

STATISTICS OF MICA IN THE UNITED STATES.
(In pounds, and tons of 2000 Lb.)

Year.	Production. (a)			Imports.			
	Sheet. (b)	Scrap.		Unmanufactured.		Cut or Trimmed.	
	Pounds.	Tons.	Value.	Pounds.	Value.	Pounds.	Value.
1900	127,241	5,417	$42,889	1,892,000	$290,872	64,391	$28,688
1901	360,600	2,171	19,719	1,598,722	299,065	78,843	35,989
1902	373,266	1,400	35,006	2,149,557	419,362	102,299	46,970
1903	619,600	1,659	25,040	1,355,375	288,783	67,680	29,186
1904	668,358	1,096	10,854	1,085,343	241,051	61,986	22,663
1905	851,800	856	15,255	1,506,382	352,475	88,188	51,281
1906	1,423,100	1,489	22,742	2,984,719	983,981	82,019	58,627
1907	1,060,182	3,025	42,800	2,227,460	838,098	112,230	77,161
1908	972,964	2,417	33,904	497,332	224,455	51,040	41,601
1909	1,809,582	4,090	46,047	1,678,482	533,218	168,169	85,595
1910	2,476,190	4,065	53,265	1,424,618	460,694	536,905	263,831
1911	1,887,201	3,512	45,550	1,087,644	346,477	241,124	155,686
1912	845,483	3,226	49,073	1,900,500	649,236	88,632	99,773
1913	1,700,677	5,322	82,543	(d)	751,092	(d)	191,926

(a) Statistics for 1901 to 1912 inclusive are those of the U. S. Geological Survey. (b) The value of sheet mica being so widely variable, and so little indicative of commercial results, and all previous statistics being of doubtful accuracy, they have been omitted from this table. (c) Includes cut or trimmed. (d) Quantity not reported.

Of the total output of sheet mica, 803,462 lb., or 47 per cent. came from North Carolina, and 731,478 lb., or 43 per cent. came from New Hampshire. The value of the North Carolina product was $230,674, an average of 28.8 cents per pound, while that of New Hampshire was only $65,765, or 8.8 cents per pound. Of the 9 producing states, Idaho, New Mexico, and South Dakota were the most prominent. A small production was recorded from Alabama, Virginia and Pennsylvania, states not previously listed as mica producers. The Virginia product is reported to have been worth $5150, or neary $1 per pound.

[1] Douglas B. Sterrett, Advance Chapter from "Mineral Resources of the United States for 1913," U. S. Geol. Surv.

Of the total output of scrap mica, a little more than one-half came from North Carolina, and was sold for $13.64 per short ton; the New Hamphsire output of 692 tons sold for $20.09 per ton.

PRICE OF SHEET MICA IN NORTH CAROLINA IN 1913, BY GRADES. (a)

Size.	Grades Nos. 1 and 2	Spotted or Slightly Clay Stained.	Black "Specked," Heavily Clay Stained.
Punch mica	$0.035	$0.035	$0.03
1½×2 in.	0.12	0.07	.....
2 ×2 in.	0.30	0.15	0.07
2 ×3 in.	0.70	0.30	0.25
3 ×3 in.	1.15	0.70	0.40
3 ×4 in.	1.35	1.00	0.70
4 ×6 in.	2.25	1.60	1.25
6 ×8 in.	4.00	2.25	1.60
8 ×10 in.	6.00	3.00	2.25

(a) U. S. Geol. Surv.

Imports into the United States in 1913 had a total value of $943,018, compared with $748,973 in 1912; classification into cut or trimmed, and unmanufactured, is stated in the first table above. The U.S. Department of Commerce ceased in 1913 to itemize the weights of imported mica, since the selling price depends upon so many variable factors of quality, amount of preparation, size of sheets, etc. Pulverized mica was imported in 1913 to the value of $4765, compared with $6611 in 1912.

Mica in Foreign Countries

Canada.—Mica is mined in Canada in the Provinces of Quebec and Ontario. In Quebec the deposits being worked are situated chiefly in the region to the north of the city of Ottawa, in the townships of Hull, Wakefield, Buckingham, Portland, and Templeton. The Ontario deposits being worked are included in an area lying directly east of the Kingston and Pembroke railway, and are located chiefly in the townships of North Burgess and South Sherbrooke in Lanark County, South Burgess in Leeds County, and in Bedford and Loughborough in Frontenac County. Some considerable development has also been done on deposits in British Columbia, particularly at Big Bend on the Columbia river, north of Donald, B. C. These latter deposits, however, are not as yet provided with transportation facilities and consequently have not yet made any production.

STATISTICS OF MICA IN CANADA.

Year.	Production.	Total Exports.	Exports to U. S. (a)	Year.	Production.	Total Exports.	Exports to U. S. (b)
1904.....	$160,777	$198,482	$137,191	1909....	$147,782	$256,834	$137,383
1905.....	178,235	179,049	121,560	1910....	143,409	299,107	287,048
1906.....	303,913	581,919	328,991	1911....	119,863	309,546	308,851
1907.....	312,599	422,172	596,321	1912....	104,393	334,054	217,868
1908.....	139,871	198,839	(b)140,166	1913....	170,112	240,775	156,097

(a) Fiscal year ending June 30. (b) Fiscal year ending March 31.

According to J. McLeish, of the Canadian Department of Mines, Canada is the only country except Ceylon in which phlogopite, or "amber mica," is known in economic quantities. Of the two varieties, phlogopite commands a higher price than muscovite, being softer, more flexible, and more suitable for use as an insulator, this being the principal use to which mica is now put. Its softness renders it particularly suitable for insulating the armatures of electric machines.

The amber-mica deposits of Canada lie in approximately 1200 square miles in the province of Quebec, and 900 square miles in the province of Ontario. The two districts are separated geographically by the Ottawa River, and geologically by a belt of sedimentary rock about 40 miles wide. The city of Ottawa lies between the two productive areas and is the seat of the mica industry, all the important works engaged in trimming and in otherwise preparing the mineral for the markets being situated there.

Deposits of white mica also occur in Canada, and occurrences of this variety (some few of which have been worked at various times) are known from Labrador to the Rocky Mountains, while several Arctic expeditions have returned with good specimens from the far north.

Though the average dimensions of mica sheets do not much exceed 3×5 in., plates of much greater size are sometimes obtained. Crystals have been found which measured over 4 ft. across and weighed nearly 2 tons. About 300 mines have been worked for mica at various times in Canada, but at the present day no more than 25 are in active operation. Among the large operators may be named: The General Electric Co., of Schenectady, N. Y.; Webster & Co., Ottawa; Blackburn Bros., Ottawa; Wallingford & Co., Ottawa; O'Brien & Fowler, Ottawa; Kent Bros. Kingston.

India.[1]—All the mica of commerce is either muscovite or phlogopite; India produces only the former. The marketable mica of India varies widely between different mines in hardness, clearness, transparency, etc., and a product having any desired qualities can generally be found in some grade.

Sporadic production has occurred in the Nilgeri Hills, Bombay, and Rajputana, but the two important fields are the Hazaribagh district of the province of Behar and Orisar, and the Nellore district, Madras Presidency. The former furnishes two-thirds of the Indian output.

Mining in Hazaribagh centers around Kodarma, a village of a few hundred inhabitants, situated 4 miles from the East India Railroad and 245 miles from Calcutta. The Kodarma (forest) mica belt extends 10

[1] Abstract of a paper by Abner F. Dixon, *Trans. Am. Inst. Min. Engrs., Bull.* 77, 1913, p. 859; *Min. Jour.*, June 21, 1913, p. 909.

miles east and west and 10 miles north and south. The areas beyond and adjacent to the forest extend another 10 to 15 miles south of Kodarma and 30 to 40 miles east, and 25 to 30 miles west of Kodarma.

The two principal rocks of the district are schist and the "dome-gneiss." The schist is the country-rock of the mica-bearing pegmatite veins, and covers the larger part of the area. The great diversity in these mica-bearing veins makes it impracticable to give any useful statement of characteristics common to them all. Valuable mica is found scattered through veins of solid quartz or feldspar, in kaolin, and in pockets surrounded by what is little more than silicified schist. The mica presents every variety, from the soft, silvery white, which competes with Canadian phlogopite, to the hard, clear "ruby," which rings like a bar of metal on being tapped. Mica with slight stains of iron oxide, or with occasional black spots, is the most common. These stains and spots are generally between the laminæ, and if not too numerous can often be removed by careful splitting. Some is densely stained, in thick sheets looking like biotite; it has a ready sale, but at a lower price. In many cases, the mica from a given mine has some peculiarity which makes it easily distinguishable, such as a few large black spots, scattered dust-like specks, dark streaks along crystallographic axes, a wavy or a flat surface, or some combination of these characteristics. The average size of the mica plates also varies from place to place. The rock is generally little altered on the surface.

The most common type of deposit is a well-defined continuous vein of quartz and feldspar with a fairly regular strike outcropping along the top of low ridges. A vein may pinch to a few inches, expand to 30 ft. or more in width, or break up into smaller veins, which join together again; but on the whole the veins of pegmatite are fairly straight and regular. The mica content, however, is far from regular; each occurrence has its peculiarities in the relation of the mica to the other constituents and to the vein itself. The most common type of workable deposit is massive quartz filling one side or the middle of the vein, with solid feldspar on one or both sides. Generally the feldspar only is mined; not because it is necessarily richer, although it seems generally to be so, but because it is softer and easier to work.

Preparation for Market.—The mica is roughly sorted by the miners; that which is obviously worthless is thrown on the dump, and the rest is made up into bundles of about 30 lb., which are brought to the store-house at the end of the day. For an extra large amount, or some unusually fine piece, the miners receive a bonus, which is generally given as a stimulus to comparative honesty. The mica is then roughly sorted according to size and given to the trimmers, who are graded according

to the size of the material they are to trim. Boys take the small pieces and well-paid men the large mica. The rough edges are cut off with a sickle-like knife, the mica being held against a stake driven into the ground and the knife at an angle of about 45 deg. to the sheet of mica.

All cracks and inclusions are cut away, regardless of what shape the pieces may assume. In the larger sizes each piece is carefully gone over and cleaned as much as possible. This is called sickle-trimmed mica. The best splitters and sorters are highly skilled men, and receive the comparatively high pay of from 7 to 16 annas per day. The mica is graded then, according to size, as follows:

Specials, over 36 sq. in.	
No. 1, from 24 to 36 sq. in	No. 4, from 6 to 10 sq. in.
No. 2, from 15 to 24 sq. in	No. 5, from 3 to 6 sq. in.
No. 3 from 10 to 15 sq. in	No. 6, from 2 to 3 sq. in.

The sizes are then re-graded according to quality, each manager having his own ideas of what the quality should be. The usual grading is into clear ruby, slightly stained, and black spotted. The silver-white soft mica is usually graded separately; but the smoky, brown, pale amber, and other varieties are mixed in with the ruby. The color of clear mica can be easily seen only in sheets over 0.25 in. thick. Stained or spotted mica, No. 6 and some No. 5, and thin sheets derived from cleaning the larger sizes, are split into films. This work is done for the most part by children, occasionally by women. Children are the best workers; older people have not the delicate touch required. The films are split with a small knife or with the thumb-nail, which is allowed to grow long. A good worker can make about 2 lb. a day; they generally do considerably less. They receive from 1 to 1 1/2 annas per pound for the splitting. The films should be so fine that a handful of them feels as soft as a bundle of tissue paper. The different sizes and grades are then packed and shipped in wooden boxes holding 100 lb. each. Some mica is cut to size, but this is uncommon in the Hazaribagh district. There is considerable speculation among natives and Europeans in buying mica in small lots, holding it until a large stock has been accumulated, and then selling it. Thus mica is often bought and sold many times before it is finally shipped. Generally in these speculative stocks all sizes and grades are mixed together, and there are many tricks to catch the unwary. It is not a game for the novice to enter.

Except F. F. Christen & Co., who have acquired mining rights over large areas outside of the Government forest, Europeans have done but little mining. The proprietors lease on a heavy nominal royalty of five-eighths of the output; but they have to take the word of the lessee as to what the output is, since there is no way to check his statement.

Present Conditions.—Throughout this district all the good veins

and many poor ones have been attacked, and worked out near the surface. But the surface as a rule has only been scratched over, even in the most developed area of the Government forest. At present only about 1 in 40 of the old workings are operating, but there is as much mining going on now as ever. As soon as one place becomes difficult to work it is abandoned for another old working that may be easier; and this, perhaps, will be left in turn, to try the first again. The recent relatively high price of the small sizes has made it more profitable to scratch around the old pits above water-level, getting out what was formerly left as too small to extract, than to take in hand the more formidable job of opening deeper and richer mines. The shallow workings are picked at again and again, bringing down the hanging-wall, and poorer and poorer ground is mined. All the mica easily available by crude methods is nearly gone, a fact which is reflected in the present high prices and small supplies. When it is considered that for many years about 14,000 men, women, and children have been engaged in mica mining, for the main part burrowing for the shallow mica, it is evident that an enormous superficial area has been gone over.

The Nellore District.—The district of Nellore in the Province of Madras is the only other important mica-bearing area in India, furnishing about one-fourth of the Indian product. There are many points of contrast between the two districts. Instead of the well-exposed hills of Hazaribagh, we have here a low-lying plain covered by recent alluvial deposits. Only an occasional outcrop of the underlying schist and pegmatite can be found. Mica has been mined on a large scale here for only 20 years, and only 35 deposits have been opened. These show lens-like masses of quartz and feldspar, encircled by schist.

The Inikuvti, the largest mine, started on a lens of pegmatite 250 × 150 ft., and dipping at an angle of 60 deg. It was worked as an open quarry to a depth of about 100 ft. On attempting to start underground mining, insufficient pillars were left; and in 1910, only one corner of the mine was accessible. There were only 3 mines working at the time, and these in only a small way. Steam pumps were used, but all rock was removed by strings of coolies carrying diminutive baskets. Wages were about the same as in Hazaribagh, but the miners are distinctly inferior physically. During the last 3 years litigation over the most important mines has hindered development. No one has been able to get a title clear enough to warrant sinking capital in development. The best mica here is a light-green variety, of which a large amount of clear sheets was formerly won; but recently only mica of somewhat inferior quality has been shipped.

The mica here, after being roughly trimmed, is cut into the largest

possible rectangle with a pair of large garden shears, one handle of which is fixed to a stake in the ground, with the cutting edge vertical. Why it is not shipped in the sickle-dressed condition, like that from Kodarma, is not apparent. There is a decided loss of value in cutting the mica into rectangles, as many uses of mica require irregular shapes, and furthermore, rectangular mica is considered as "manufactured" under United States tariff rules, and pays 10 cents per pound duty plus 20 per cent. ad valorem, while sickle-dressed pays only 5 cents per pound and 20 per cent. ad valorem. Since the United States is the largest importer of mica, this is a point of material importance in shipping mica to the general market.

London Mica Market in 1913.—Messrs. Baker & Startin's report on the mica market states: Demand was fairly good throughout 1913, although somewhat less active during the latter portion of the year. No fresh sources of supply worth mentioning were developed, and practically the whole of the arrivals of block mica, both from Calcutta and Madras, were absorbed by the trade. Calcutta: Values declined toward the end of the year, more especially of the smaller grades of stained quality. Madras: All sizes and qualities found ready buyers, and no material change in values occurred. Regular supplies of all electrical qualities were received, and prices were firm at the close of the year. Sundry: Several parcels of African amber were marketed, and somewhat improved prices realized. Splittings: A general slackening in the demand, and prices ruling in buyers' favor with the exception of choice qualities, the small supplies of which caused active competition. Late in the year, importers were holding back the lower grades, of which large stocks accumulated during the previous 6 months. The following figures are compiled from the returns of the London warehouses:

		Arrivals.	Deliveries.	Total Warehouse Stocks, Dec. 31.
Cases (about 100 lb. each)	1913.....	40,174	30,115	19,405[1]
Cases as compared with	1912.....	31,315	29,411	9,346[1]
Cases as compared with	1911.....	23,236	20,972	7,502[1]

At the periodical sales, occurring every 3 weeks, Indian mica predominates, with sporadic offerings from South Africa, Australia, Ceylon, Japan, Mexico, Bengal, and Canada. Most of the mica imported into New York is purchased in London, but mica is sold on contract by large purchasers in India to Germany and the United States direct. Most of the Indian shipments are made by 10 or 12 firms which operate mines and buy the output of small producers. Artificial fluctuations produced by speculators, as well as the varying demand for different grades, make it difficult to estimate the market value of a given lot of mica.

[1] Including goods sold but uncleared.

MOLYBDENUM

By James Aston

The molybdenum industry in the United States was in about the same position during 1913 as for some years back. There was a limited importation of ore and metal, and some manufacture of molybdenum and ferro-molybdenum, but no mining of ore on a commercial scale in this country. There was a small increase of production for 1913 over 1912, and the price of foreign ores reached a record price; but the total consumption in the United States was only 18 tons of contained molybdenum, a quantity too small to warrant the development of ore properties in this country.

The Primos Chemical Company, Primos, Pa., the important producer, states that the demand was very irregular during the year, and that the tool steel industry, formerly the largest consumer of molybdenum, used less than 5 tons of contained molybdenum in 1913. This was in large part due to the depression in the steel trade, but may in a measure be the result of a preference on the part of the steel maker for tungsten as a steel hardening agent. Molybdenum is used together with or as a substitute for tungsten, and plays an analogous rôle as an addition agent in steel, except that about double the quantity of the latter element is necessary for the same result.

During the Balkan war, ore prices went up to $12.50 per unit of molybdenum sulphide, the highest point since 1900; but there has since been a decline to about $9.00. The price of the ore is subject to considerable variation, and is easily demoralized by any large shipment. A standard ore should contain a minimum of 85 per cent. of MoS_2, and such an ore would be worth from $8 to $10 per unit, provided it is free from copper, arsenic, bismuth, and tungsten. Any of these elements will reduce the price of the ore.

It is stated that since the passage of the new tariff law of Oct. 3, 1913, Europe has a virtual monopoly of the market, since production in this country becomes practically impossible. Under the old schedules (Act of 1909), the duty on molybdenum or ferro-molybdenum was 20 per cent., if valued at more than $200 per ton, and 25 per cent. for that valued at less. The new rate is 15 per cent. in all cases. In both schedules, crude ore is on the free list.

During 1913, considerably more than half of the molybdenite ore of the world came from Australia, mostly from Queensland. No develop-

ment work of commercial importance was carried out in the United States, nor was there any commercial production reported in Canada; but in the latter country there was some prospecting activity in Ontario, Quebec, and British Columbia. It is reported that a mine in the latter province which shows much molybdenum ore loaded a carload of high-grade material for milling in Denver; and a small trial shipment of Ontario ore was made to England. Also, it is of interest to note that several hundred pounds of an Arizona ore of 80 to 90 per cent. MoS_2 was milled for experiment.

The only ore of importance is molybdenite, MoS_2. It is widely distributed, and occurs in England, Scotland, Austria, Canada, France, Germany, Russia, Norway, Sweden, United States, Australia, Japan, and Mexico. The difficulty of commercial utilization is largely one of concentration; the molybdenite is very soft and flaky, and is found in association with harder rocks. In crushing, a large proportion of the molybdenite becomes powdered, and there is much loss in sliming. If the flakes are of sufficient size they can be separated by screening and hand picking. Normally, molybdenite is heavy enough to be separated by washing, but with the slightest pressure the crystals split into fine scales or powder, and are floated away in spite of their relatively high density. Oil flotation promises to be of service, due to the selective action of the oil for the molybdenite particles. The greasy flakes become wet with an oil film, and float, while the gangue material of the water-mixed pulp settles. In this way a concentrate of upward of 90 per cent. of MoS_2 is secured. Also, as shown by experiments in Australia, an extraction of 86 to 90 per cent. of the contained molybdenite is feasible.

A correspondent writes to *Engineering and Mining Journal*[1] that lack of satisfactory methods for the treatment of molybdenite ores has been the chief retardant of production of this valuable mineral. The author has experimented with an ore carrying chalcopyrite, which under ordinary circumstances floats almost as readily as molybdenite, and thus by failure in its elimination and its presence in the concentrates, the latter are practically unsalable. His method is to grind the ore, then dampen and dry it. Under these conditions, the partial oxidation of the chalcopyrite causes practically every particle to sink, while the molybdenite will float. By this treatment 90 per cent. of the MoS_2 can be recovered, and it becomes profitable to treat 3 per cent. ores, provided there are no other contaminating sulphides present, and the gangue is amenable to flotation.

In Norway, ore of 1/2 per cent. of MoS_2 is being profitably worked, owing to the cheapness of water power.

The United States Bureau of Mines is taking an interest in the smelt-

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

ing, especially by electrical means, of molybdenum ores.[1] It is pointed out that the electric furnace has generally replaced other methods, and produces molybdenum metal or ferro-molybdenum by reduction of the roasted ore, or directly from the sulphide. The widespread use of the metal or alloy is prevented by irregularity of ore supply, and consequent high cost. The principal drawback is the lack of satisfactory methods for concentration. Experimental work of the Bureau has progressed sufficiently to show that ferro-molybdenum low in carbon can be made directly from molybdenite in the electric furnace, with excess of lime as a desulphurizing agent; and that the sulphur can be readily slagged off as calcium sulphide.

Other than as ferromolybdenum for use in steels, the salts of molybdenum, as ammonium molybdate and molybdic acid, are used in chemical laboratories, as a blue pigment in the manufacture of porcelain, in dyeing of silks and woolens, and for coloring leather and rubber. The steel industry uses several tons of molybdenum annually in the form of ammonium molybdate as a chemical reagent for the determination of phosphorus in steels.

Bibliography

Barham, G. B.—Molybdenum, Its Preparation for Market and Varied Uses. *Min. Jour.*, Dec. 20, 1913.

Hanig, A.—Modern Ferro-Alloys and Their Application in the Iron and Steel Industry. *Elektrochem. Zeit.*, Nov., 1913.

Haynes, Elwood.—Cobalt-Chromium-Molybdenum Alloys. *Bull. Am. Inst. Min. Engrs.*, 1913.

Mennicke, Hans.—The Metallurgy of Molybdenum and Vanadium. *Elektrochem. Zeit.*, Oct., 1913.

Sweezey, R. O.—Molybdenite Deposit at Turn Back Lake, Quebec. *Can. Min. Jour.*, Mar. 15, 1913, p. 190.

Swinden, Thos.—Constitution of the Carbon-Molybdenum. *Jour. Iron & Steel Inst., Carnegie School, Mem.*, Vol. V, 1913.

Walker, T. L.—Metallurgy of Molybdenum. *Met. Chem. Eng.*, Feb., 1913, p. 110.

[1] R. M. Keeney. *Trans. Amer. Electrochem. Soc.*, XXIV, 167, 1913.

MONAZITE SAND[1]

The mineral monazite is composed essentially of phosphates of the cerium and lanthanum earths, but also contains invariably a certain proportion of thoria, and hence forms the principal commercial source of the thorium nitrate employed in making the mantles used for incandescent gas lighting.

Monazite crystallizes in the monoclinic system, and varies in color from pale yellow to dark reddish brown or occasionally black. Its specific gravity is usually about 5.2 but sometimes samples are met with, such as those described later on from Ceylon, having a specific gravity of nearly 5.5.

The production of monazite in the United States has practically ceased, owing to the fact that the local product cannot compete with the imported material with the import duty only 4 cents a pound on monazite and 40 per cent. on thorium nitrate. The history of the production of monazite in the United States is summarized in the following table of production.

MONAZITE PRODUCTION IN THE UNITED STATES.

Year.	United States. (a)			North Carolina. (b)		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Per Pound.
1894	546,855	36,193	0.066	364,570	24,129	0.066
1895	1,573,000	137,150	0.087	1,048,667	91,433	0.087
1896	30,000	1,500	0.050	20,000	1,000	0.050
1897	44,000	1,980	0.045	29,333	1,320	0.045
1898	250,776	13,542	0.054	167,184	9,028	0.054
1899	350,000	20,000	0.057	233,333	13,333	0.057
1900	908,000	48,805	0.054	605,333	32,537	0.054
1901	748,736	59,262	0.079	499,157	39,508	0.079
1902	802,000	64,160	0.080	534,667	42,773	0.080
1903	862,000	64,630	0.075	773,000	58,694	0.076
1904	745,999	85,038	0.114	685,999	79,438	0.116
1905	1,352,418	163,908	0.121	894,368	107,324	0.120
1906	846,175	152,312	0.180	697,275	125,510	0.180
1907	547,948	65,754	0.120	(c)456,863	54,824	0.120
1908	422,646	50,718	0.120	(c)310,196	37,224	0.120
1909	541,931	65,032	0.120	(c)391,068	46,928	0.120
1910	99,301	12,006	0.121	83,454	10,104	0.121
1911	3,561	427	0.120	400	48	0.120
1912	1,272	159	0.12	*Nil.*	.....	.....

(a) Statistics are those of the U. S. Geological Survey. (b) Statistics for N. C. from 1893 to 1902 are estimates; those from 1903 to 1906 are from "The Mineral Industry of North Carolina"; those for 1910 are furnished by Joseph Hyde Pratt, State Geologist. (c) Statistics for 1907, 1908, and 1909 were collected jointly by the U. S. Geological Survey and the N. C. Geological and Economic Survey.

[1] Abstracted from the article "Monazites from Some New Localities" by Sydney J. Johnstone, *Jour. Soc. Chem. Ind.*, Jan. 31, 1914, with the addition of the data from the United States.

The following table shows the imports of thorium nitrate and of monazite in recent years:

IMPORTS OF THORIUM NITRATE AND MONAZITE. (*a*)

	Year.	Pounds.	Value.	Per Pound.
Thorium nitrate entered for consumption.....	1902	42,815	$131,350	$3.07
	1903	64,520	232,155	3.59
	1904	58,655	249,904	4.26
	1905	52,378	269,504	5.14
	1906	40,090	139,929	3.49
	1907	51,441	152,666	2.96
	1908	65,289	173,239	2.65
	1909	125,088	236,057	1.89
	1910	108,597	218,713	2.01
	1911	121,111	238,841	1.97
	1912	117,485	225,386	1.92
	1913	112,105	212,263	1.89
Monazite sand (and thorite) entered for consumption.....	1909	110,088	9,543	0.0867
	1910	453,554	39,699	0.0875
	1911	705,149	60,542	0.086
	1912	556,959	47,334	0.085
	1913	1,145,010	94,425	0.082

(*a*) Statistics from 1902 to 1908 are those of the U. S. Geological Survey; those for 1909 and 1910 were furnished by the Bureau of Statistics of the Department of Commerce and Labor.

A large proportion of the monazite used industrially is obtained from deposits in Brazil, where the 1912 exports amounted to 3398 metric tons. The most extensively worked deposits in Brazil are the naturally concentrated sands on certain parts of the seacoast, and the monazite separated from these, contains on the average from 5.0 to 7.0 per cent. of thoria. The less important deposits inland yield monazite containing from 4.0 to 5.7 per cent. of thoria.[1]

During the past 2 years an important contribution to the world's production of monazite sand has been made by the native State of Travancore in India. The output in 1911 amounted to 811 tons valued at £24,044 and in 1912 this had increased to 1135 tons valued at £41,419.

In the course of the mineral surveys conducted in recent years in connection with the Imperial Institute in Ceylon, southern Nigeria, northern Nigeria, and Nyasaland, many concentrates have been obtained which proved to contain monazite. The occurrence of this mineral had not previously been recorded from these countries, and particulars of the occurrences will be found in the official reports on these surveys which are published periodically in the Miscellaneous Series of Colonial Reports (London: Wyman and Sons). Similar concentrates have also been received at the Imperial Institute from Travancore and from Malaya. Analyses of monazites from all these sources have been made.

The materials received at the Imperial Institute have been mostly in the form of sands already concentrated by washing. They contained numerous minerals other than monazite, and in such cases the mona-

[1] MINERAL INDUSTRY, 1909, 18, 537.

zites were separated from the concentrates by electro-magnetic[1] or electrostatic[2] means. In a few cases, the monazite examined consisted of a single fragment weighing several grams.

The results obtained in the analyses of these new monazites are shown in the following tables.

From these results and numerous partial analyses made at the Imperial Institute it is evident that the Ceylon monazite usually contains about 10 per cent. of thoria, which is nearly double the amount found in the monazite of Brazil. As little as 5 per cent. of thoria has been found in certain monazite sands from Ceylon, but material of this character appears to be of somewhat infrequent occurrence. Occasionally, specimens are met with having an unusually high specific gravity and a correspondingly high percentage of thoria, sometimes over 28 per cent. (column 5 in Table I). The Ceylon monazite in general is very similar in composition to one of the Norwegian varieties the analysis of which is given in Table VI.

TABLE I.—CEYLON MONAZITE.

Locality.	1. Monazite Pebble from Aninkanda Morawak Korle.	2. Monazite Pebble from Muladiwanella Durayakanda, Gilimale.	3. Sand from Niriella Ganga.	4. Monazite pebble from Ratnapura.	5. Monazite Pebble from Ratnapura.
Thoria, ThO_2	9.75	9.49	10.75	10.29	28.20
Ceria, Ce_2O_3	27.51	27.15	26.71	27.37	20.65
Lanthana and allied oxides, La_2O_3, etc	29.59	29.59	30.06	30.13	21.63
Yttria and allied oxides, Y_2O_3, etc	2.54	3.93	1.46	2.14	0.94
Ferric oxide, Fe_2O_3	1.27	0.87	1.09	0.81	1.13
Alumina, Al_2O_3	0.61	0.17	0.70	0.17	0.29
Lime, CaO	.....	0.45	0.85	0.41	0.10
Silica, SiO_2	1.78	1.67	2.47	1.03	6.09
Phosphoric acid, P_2O_5	26.12	26.12	27.67	27.67	20.20
Loss on ignition	0.59	0.48	0.93	0.20	.....
Specific gravity	5.20	5.25	.....	5.23	5.47

TABLE II.—TRAVANCORE MONAZITE.
Two specimens of this monazite gave the following results.

	No. 1. Per cent.	No. 2. Per cent.
Thoria	10.22	8.65
Ceria	31.90	} 61.11
Lanthana and allied oxides	28.00	
Yttria and allied oxides	0.46	0.62
Ferric oxide	1.50	1.09
Alumina	0.17	0.12
Lime	0.20	0.13
Silica	0.90	1.00
Phosphoric acid	26.82	26.50
Loss on ignition	0.46	0.45

Isolated from a concentrate supplied by Mr. I. C. Chacko, B. Sc., State Geologist, Travancore.

[1] T. Crook, *Science Progress*, **2**, 30, 1907.
[2] T. Crook, *Mineralogical Magazine*, **15**, 260, 1911; **16**, 109, 1909.

These analyses show that the monazite of Travancore contains a high percentage of thoria approaching that of ordinary Ceylon monazite. According to E. White[1] from 6 to 14 per cent. of thoria has been found in Travancore monazite.

Malayan Monazite

Monazite sand has been found in many localities in the Federated Malay States and the protected States of Kedah and Kelantan in association with alluvial tinstone.[2]

In Table III are the results of analyses of samples of typical monazites from the source received at the Imperial Institute.

TABLE III.

Locality.	No. 1. (*a*) Pahang.	No. 2. (*a*) Puchong Babi, Rvier. Kenring, Perak.	No. 3. (*a*) Kulim, Kedah.	No. 4. Kelantan.
Thoria	8.38	3.40	3.53	9.41
Ceria	25.46	33.74	} 64.05	60.00
Lanthana and allied oxides	32.72	32.53		
Yttria and allied oxides	2.80	0.91	2.40	2.82
Ferric oxide	0.84	0.65	0.64	} 1.13
Alumina	2.78	0.03	0.07	
Lime	0.61	0.33	0.17	0.29
Silica	0.92	1.45	1.08	2.20
Phosphoric acid	23.92	26.58	27.87	23.71
Loss on ignition	1.28	0.94	0.52	0.94

(*a*) Isolated from concentrates supplied by Mr. J. B. Scrivenor, M. A., F. G. S., State Geologist, Federated Malay States.

These results show that there are wide variations in the percentage of thoria in monazite from Malaya, from the Perak specimen containing only 3.4 per cent. to that from Kelantan, which contained over 9 per cent. and is superior in this respect to the average Brazilian material.

Nyasaland Monazite

The following are the results of an analysis of monazite separated from a concentrate obtained from a stream at Namalundo Hill, near Chiromo, in the Nyasaland Protectorate:

TABLE IV.

	Per cent.
Thoria	7.10
Ceria	32.52
Lanthana and allied oxides	26.91
Yttria and allied oxides	1.50
Ferric oxide	1.10
Alumina	0.20
Lime	0.32
Silica	1.66
Phosphoric acid	28.16
Loss on ign tion	0.25

From the results of numerous partial analyses at the Imperial Institute, by the author, on other samples of monazite from Nyasaland, it would appear that the average thoria content is about 6 per cent.

[1] "Thorium and its Compounds," p. 10.
[2] *Bull. Imp. Inst.*, 4, 301, 1906; 9, 99, 1911.

It would appear from analyses Nos. 4 and 5 (Table V) that monazite from different parts of the same locality and apparently derived from the same source, may contain widely different percentages of thoria, but further work is necessary to confirm this point, which is of some considerable scientific and commercial importance, particularly as monazite of the grade of sample No. 5 would not repay export to Europe. The above results show that the percentage of thoria in monazite from Nigeria may vary between fairly wide limits. The average thoria content of a large number of Nigerian monazites examined by the author is 5.5 per cent. for those from Northern Nigeria and 5.8 per cent. those from Southern Nigeria. The results show that these monazites, as a whole, are nearly as rich in thoria as those exported from Brazil.

For comparison with the foregoing results the following analyses of other monazites may be given (Table VI).

TABLE V.—NIGERIAN MONAZITE.

Number.	Northern Nigeria.			Southern Nigeria.		
	1.	2.	3.	4.	5.	6.
Locality.	Ekole.	Kadera, Central Province.	Jarawa River, Naraguta.	Iboboto Stream, Nsan-Oban Track.	Between Iboboto Stream and Ebara River.	Ebara River.
Thoria	5.00	3.20	8.00	6.19	2.30	5.50
Ceria	30.72	36.53	30.50	30.38	34.58	31.40
Lanthana and allied oxides	30.02	30.00	28.80	29.60	29.83	29.20
Yttria and allied oxides	2.74	0.39	1.43	1.33	1.29	2.00
Ferric oxide	3.00	1.20	0.81	1.50	1.80	0.75
Alumina	0.35	0.10	0.20	0.10	.....	0.05
Lime	0.15	0.21	0.17	0.16	0.19	0.10
Silica	1.20	0.63	1.79	0.85	0.73	0.82
Phosphoric acid	26.29	28.29	28.16	29.70	29.71	29.92
Loss on ignition	0.25	0.20	0.21	0.33	0.21	0.44

TABLE VI.

	1. Brazil.		2. United States.		3. Canada.	4. Australia.	5. S. Norway.
	Espirito Santo.	Alcobaca, Bahia.	Amelia County, Virginia.	Burke County, North Carolina.	Ottawa County, Quebec.	Emmaville, New South Wales.	—
Thoria	6.06	6.50	14.23	6.49	12.60	1.23	9.34
Ceria	62.12	61.40	29.89	31.38	24.80	36.64	28.06
Lanthana and allied oxides.			26.66	30.88	26.41	30.21	29.60
Yttria and allied oxides.	0.80	0.70	.....	.....	4.76	.....	1.82
Ferric oxide	0.97	1.50	.....	.....	1.07	.....	0.66
Alumina	0.10	0.08	.....	.....	.....	3.11	0.16
Lime	0.21	0.30	.....	.....	1.54	.....	0.53
Silica	0.75	0.64	2.85	1.40	0.91	3.21	1.65
Phosphoric acid	28.50	28.46	26.12	29.86	26.86	25.09	28.27
Loss on ignition	0.38	0.64	0.67	0.20	0.78	.....	0.21

1. S. J. Johnstone. 2. S. L. Penfield, *Amer. Jour. Sci.*, **24**, 250, 1882. 3. F. A. Genth, *Amer. Jour. Sci.*, **38**, 203, 1889. 4. C. Watt, *Min. Res.*, New South Wales, p. 86 (Sydney, 1910). 5. C. W. Blomstrand, *Geol. Föreningens Förhandl.*, **9**, 160, 1887.

The Constitution of Monazite

The question of the state of combination of the thoria in monazite has received attention from various investigators.

Penfield[1] has suggested that monazite is a normal phosphate of the cerium earths and that thoria is present as an impurity, probably as the silicate thorite, and supports his view with numerous analyses, which show the ratios $(Ce,La,Di)_2O_3:P_2O_5=1:1$ and $ThO_2:SiO_2=1:1$. He also reported the occurrence in monazite of a substance which appeared "resinous" under the microscope and which he considered to be thorite. This veiw is supported by evidence adduced by Rammelsberg,[2] Dunnington[3] and others. Blonstrand,[4] on the other hand, considers that the mineral is a normal tribasic phosphate and that the excess of bases is combined with silica thus:

$$m(3RO,P_2O_5)+2RO,SiO_2+pH_2O$$

where m may vary from 5 to 20 and p is less than 1. He does not support Penfield's thorite theory, but considers rather that thoria is a primary constituent of the mineral, occurring as phosphate in isomorphous admixture with the cerium phosphate. He attributes the presence of silica to alteration by siliceous waters.

Kress and Metzger,[5] from a consideration of numerous partial analyses of monazite from Norway and North Carolina, conclude that thoria is present as phosphate and that the silica belongs to some unidentified silicate other than normal thorium silicate, but in almost every case they record percentages of silica which increase with those of the thoria. They could not detect the presence of the "resinous" constituent mentioned by Penfield.

In considering this question in relation to the analyses now presented, it is evident that those made on sand grains cannot be considered owing to the risk of inclusion, in the sample examined, of quartz in minute particles or dust. In these circumstances the only analyses in this communication available for discussion are those made on massive monazites from Ceylon. When these analyses are considered in relation to the views quoted above it is evident that they do not support Penfield's theory, for in no case is there sufficient silica present to combine with *all* the thoria to form the normal silicate $ThO_2.SiO_2$.

As regards the theory of Kress and Metzger (who do not support their conclusions by complete analyses) that the thoria is all present as phosphate, the analyses given in this paper do not show sufficient phosphoric acid to combine with the remaining cerium earths. Thus it would have

[1] Penfield, *Amer. Jour. Sci.*, **24**, 250, 1882; **26**, 322, 1888.
[2] Rammelsberg, *Zeits für Kryst*, **3**, 101, 1879.
[3] Dunnington, *Amer. Chem. Jour.*, **4**, 138, 1882.
[4] Blomstrand, *Zeits. für Kryst*, **6**, 160, 1887; **20**, 367, 1892.
[5] O. Kress and F. J. Metzger, *J. Amer. Chem. Soc.*, **31**, 640, 1909.

to be concluded, if the theory of these authors be adopted, that part of the cerium earths is present as silicate or as oxides and on this point, at present, no evidence is available.

An attempt was made to detect the presence of thorium silicate in monazite by taking advantage of the fact that thorite, when reduced to the same state of subdivision, is more readily soluble in hot concentrated nitric acid than is monazite. 1.8 grm. of finely ground Ceylon monazite containing 10 per cent. of thoria was heated for half an hour with concentrated nitric acid and the rare earths estimated in the filtrate. The experiment was repeated, using concentrated hydrochloric acid in place of nitric acid. The following is a summary of the results obtained:

	Weight of Rare Earths in Solution.	Weight of Thoria in Solution.	Ratio of Thoria to Rare Earths Extracted.	Ratio of Thoria to Rare Earths in Mineral.
	Gram.	Gram.	Per cent.	Per cent.
Nitric acid	0.1130	0.0223	19.7	14.03
Hydrochloric acid	0.2200	0.0390	17.7	14.03

These results indicate that the thorium constituent is slightly more readily attacked by concentrated acids than the cerium earth phosphates, but the difference is not sufficiently great to make an efficient separation possible. The results indicate, however, that there is in monazite a thorium constituent which is more readily soluble in nitric or hydrochloric acid than the cerium earth phosphates.

Further experiments showed that natural hydrated thorium silicate, in the form of the mineral thorite, shows practically no difference, as regards its behavior with acids, from ignited artificial thorium and cerium phosphate.

It does not appear likely that experiments designed to separate thorium silicate from thorium phosphate and cerium phosphate will, even if successful, prove of general application to monazite, as experiments have shown that the solubility of thorite in acids is to a very large extent dependent on the state of hydration of the mineral. Thorites containing from 2 to 6 per cent. of combined water are attacked by nitric acid with the greatest difficulty, while those containing over 8 per cent. of water are readily decomposed.

From the results of the analyses given in this paper it is seen that the combined water in monazite varies between 0.2 and 1.2 per cent.

It would therefore appear that if the problem is to be attacked from a solubility standpoint it would be necessary to consider the relative rates of solution of cerium phosphate and silicate and of thorium phosphate and silicate in nitric acid. Unfortunately, the available minerals containing these compounds occur in various degrees of hydration and are therefore not of service in this connection.

NICKEL AND COBALT

By James Aston

The United States is practically a non-producer of nickel, since there was no mining of its ores during the year. Any output of nickel from domestic ores was obtained as a by-product in the electrolytes of copper refineries. Salts and metal equivalent to 328 short tons of nickel were thus obtained in 1912 from foreign and domestic ores.

The only plants in the United States producing nickel were the Orford Works of the International Nickel Co. at Constable Hook, N. J., and a small refinery of the United States Nickel Co. at New Brunswick, N. J. The former production was entirely from nickel matte imported from Canada; while the latter refines matte shipped from Europe. There were no new districts or prospects developed in this country in 1913, nor was there any notable change in the metallurgy of extraction.

The importation of nickel into the United States was as follows:

1911	29,545,967 lb.
1912	42,168,769 lb.
1913	47,124,330 lb.

Exports of nickel amounted to 29,173,088 lb. in 1913, and 25,815,016 in 1912. These figures include the metal in ores, matte, bullion, etc., and for import are mainly matte, while for export they represent almost entirely the shipments of metallic nickel. The tabulated summary for recent years is given below.

Year.	Imports.							Exports.	
	Nickel Ore and Matte.		Nickel Alloys. (a)		Nickel Mnfrs.	Cobalt Oxide.		Nickel. (b)	
	Long Tons.	Value.	Pounds.	Value.	Value.	Pounds.	Value.	Pounds.	Value.
1900.	25,670	$1,183,884	(c) 455,188	$139,786	.....	54,073	$88,651	5,869,906	$1,382,727
1901.	52,111	1,637,166	635,697	209,956	$ 2,498	71,969	134,208	5,869,655	1,521,271
1902.	14,817	1,156,372	752,630	251,149	30,128	79,984	151,115	3,228,607	925,579
1903.	15,936	1,285,935	521,344	170,670	37,284	73,350	145,264	2,414,499	703,550
1904.	8,548	915,470	589,555	203,071	2,950	42,352	86,925	7,519,206	2,130,933
1905.	13,451	1,626,920	941,966	331,920	3,291	70,048	139,377	9,550,918	2,894,700
1906.	15,156	1,816,631	210,000	77,373	8,963	41,084	83,167	10,620,410	3,493,643
1907.	(d)16,888	2,153,873	180,025	80,994	9,159	48,013	74,849	8,772,578	2,845,663
1908.	(e)16,322	2,396,217	241,868	91,388	10,010	219,098	17,077	9,770,248	3,297,988
1909.	(f)18,578	2,927,975	277,911	104,019	4,279	12,132	11,096	12,048,737	4,101,976
1910.	(g)28,519	4,085,076	323,239	125,013	14,759	6,124	4,806	15,244,937	4,704,088
1911.	(h)23,993	3,918,556	293,301	104,160	.....	14,561	7,576	25,099,586	8,283,777
1912.	(i)33,101	5,638,456	(j)223,168	103,300	17,203	31,848	15,132	25,815,016	8,515,332
1913.	(k)37,582	6,423,423	(l) 12,526	(l) 122,702	(l) 43,809	(l) 28,729	(l) 14,405	29,173,088	9,686,794

(a) Includes nickel oxide, and alloys of any kind in which nickel is the material of chief value, in ingots, bars, and sheets. (b) Comprises domestic nickel, nickel oxide, and matte. (c) Not separately enumerated; included in "Nickel Ore and Matte." (d) Contained 18,418,305 lb. nickel; not reported previous to 1907. (e) Contained 16,586,423 lb. nickel. (f) Contained 21,916,182 lb. nickel. (g) Contained 32,050,032 lb. nickel. (h) Contained 29,545,967 lb. nickel. (i) Contained 42,168,769 lb. nickel. (j) Weight of nickel alloys only, value $85,059. (k) Contained 47,124,330 lb. nickel. (l) Fiscal year.

The price of nickel remained constant throughout the year, and New York quotations were 40 to 45 cents per pound on contract for large lots. Electrolytic nickel quotations were from 45 to 50 cents for large lots.

The tariff changes under the new act of October 3, 1913, are as follows, as applying to nickel products.

	Old	New
Oxide of	6 cents per pound	10 per cent. adv.
Metal and alloys where nickel is chief value.	6 cents per pound in pigs, ingots, rods, bars and plates. 35 per cent. adv. in strips or sheets.	10 per cent. adv. in pigs, ingots, rods, bars and plates. 20 per cent. adv. in sheets or strips.
Articles or wares of	45 per cent. adv.	20 per cent. adv.
Ores of	Free	Free.
Matte	Free	Free.
Alloy steel	½ to 7 cents per pound according to value, and 20 per cent. above 40 cents per pound.	15 per cent. adv.

The International Nickel Co. is the all-important producer in this country.[1] Its annual report for the year ending March 31, 1913, states that there was a greatly increased demand (the best in the history of the company) for nickel from the steel makers and in other industries. Profits for the year were $5,020,305, apportioned as dividend on preferred stock $534,754, on $38,031,500 of common $3,491,049, and as balance carried forward $994,501. During the year $1,323,276 was spent for new construction, equipment, and property, and $225,033 for development and diamond drilling. Besides its refinery in the United States, this company also controls plants in Great Britain, and mines and smelters in Canada and New Caledonia.

The world's nickel policy is practically controlled by the above company, together with Le Societe de Nickel, owned by the Rothschilds, and the Mond Nickel Co., with mines and smelter in Canada, and matte refining plant in Wales. Recently the Rothschilds, heretofore operating exclusively in New Caledonia, are reported to have been acquiring properties in Canada, and this is taken as indicative of an impending break in the amicable trade relations of the large companies, and a desire of the French interests to get an assured source of cheap ore to augment the failing supply of the New Caledonia mines.

Canada.—The interest of the United States in the nickel industry naturally centers in the Canadian development because of (1) its position in the lead of nickel ore producers, (2) the greater part of its nickel is brought to the United States for further treatment, (3) the dominant position in its workings of an American company, and (4) the rapid growth of the industry, one which is due to continue in view of the constantly increasing difficulty of the New Caledonian fields to keep in competition.

The world's production of nickel has increased from 14,000 to 26,500 metric tons between 1906 and 1912. Canada's proportion has been from 65 to 93 per cent.; 85 per cent. being the figure for 1912. The past

[1] *Eng. Min. Jour.*, Nov. 29, 1913.

year was one of great activity, and there was a greatly increased output of nickel ores. Itemized statistics for Canadian production are given in the following table:

CANADIAN PRODUCTION AND EXPORT.
(From Preliminary Report, Mineral Production of Canada—1913.)

	1910 Tons of 2000 lb.	1911 Tons of 2000 lb.	1912 Tons of 2000 lb.	1913 Tons of 2000 lb.
Ore mined	652,392	612,511	737,584	784,697
Ore smelted	628,947	610,834	725,065	823,403
Bessemer matte produced	35,033	32,607	41,925	47,150
Copper content of matte	9,630	8,966	11,116	12,938
Nickel content of matte	18,636	17,049	22,421	24,838
Spot value of matte	$5,380,064	$4,945,592	$6,303,102	$7,076,945
	Lb.	Lb.	Lb.	Lb.
Nickel contained in matte, etc.:				
Exported to Great Britain	5,335,331	5,023,393	5,072,867	5,164,512
Exported to United States	30,679,451	27,596,578	39,148,993	44,224,119
Exported to Other Countries	.....	.....	.....	70,386
	36,014,782	32,619,971	44,221,860	49,459,017

The United States received 89 per cent. of the nickel. There were also produced at Canadian plants nickel oxide, cobalt oxide, and cobalt material, speiss, etc., not all completely refined, amounting to 1,644,185 lb., compared with 399,054 lb. for 1912.

During the year there have been several notable additions to the literature of the Canadian nickel deposits; of especial mention is the monograph[1] of Dr. A. P. Coleman. This is an exhaustive review of the geology and economic aspects of the Canadian deposits, including the mining and metallurgical practice; also there is a summary of the situation in other parts of the world.

Minerals containing nickel have been found in a number of localities throughout Canada,[2] but the important commercial deposits at present are the Cobalt and Sudbury districts, both in Ontario. Deposits of lower grade and not exploited are known in other localities of Ontario, in New Brunswick, and British Columbia.

Several nickel-bearing minerals have been reported from the Sudbury region, but pyrrhotite and pentlandite are the only ones having important relation to the ore deposits. In addition, chalcopyrite is almost invariably present. At the important Copper Cliff and Crean Hill mines, copper is present in larger amounts than nickel; at the Garson and Victoria mines

[1] Canada Dept. of Mines, *Bull.* No. 170.
[2] Economic Minerals of Canada, No. 230.

they are about equal; while at all others the nickel exceeds the copper content. It is estimated that there are fully 100,000,000 tons of sulphide ores, workable and unworkable, along the whole of the Sudbury range, with an average width of nickel eruptive of about 3 miles. The ores are of variable metallic content, with averages about 2.09 per cent. nickel and 1.80 per cent. copper, after roasting and smelting, or probably 3.09 nickel and 2.12 copper, total 5.21 per cent., in the raw ore, assuming 15 per cent. of loss. Cobalt is also present in all of the ores, to a fraction of a per cent. in the ore, and in negligible amounts in the matte, because of being slagged off in smelting. Matte analyses give about 40 to 49 per cent. nickel, 25 to 45 per cent. copper, up to 10 per cent. iron, and small amounts of precious metals.

The situation is dominated by two companies, the International Nickel Co., discussed previously, and the Mond Nickel Co., with headquarters in England. The latter has a capitalization of $4,130,000,[1] and in 1912 mined 117,568 tons of the total production of 737,584 tons of ore. All of the ore is refined in Wales after preliminary smelting to matte at its works in Ontario. During the year this company completed its new smelter at Coniston and further fortified its position by extending its ore resources by exploration and by purchase of the Big Levack mine and an extension of the Frood deposit.

During the year the Canadian Copper Co., the operating branch of the International Nickel Co., improved and enlarged its smelting plant[2] at Copper Cliff, and in September began operations at the Frood, or No. 3 mine, after a shut down of 10 years. An enormous body of ore has been proved, estimated at 35,000,000 to 50,000,000 tons. It is of lower grade than the Creighton, the chief producing mine of the company. When last worked the composition was 2.66 per cent. nickel and 1.39 per cent. copper. Working shafts to provide for a daily output of 10,000 tons of ore are being sunk, and modern equipment installed.

The proven ore reserves of the company were also greatly increased by additional exploration and purchases of outside holdings. Additional hydro-electric power installation is being planned. About 80 per cent. of Canada's total nickel-copper production comes from the mines of this company.

The extensive holdings of the Dominion Nickel-Copper Co. (Booth-O'Brien syndicate) passed to the control of interests headed by Dr. F. S. Pearson.[3] A new company known as the British-American Nickel Co. was organized with $30,000,000 capital stock. Control of 17,500 acres in the Sudbury district is announced, including eight proper-

[1] Alex. Gray, *Jour. of Commerce*, Sept. 13, 1913.
[2] *Eng. Min. Jour.*, Jan. 10, 1914.
[3] *Eng. Min. Jour.*, Jan. 10, 1914.

ties, the principal one being the Murray mine, with ore to the extent of 4,600,000 tons blocked out. A total tonnage of 6,800,000 is claimed to be in sight. Erection of a treatment plan was commenced, but later suspended. Announcement is that development and equipment work will be resumed in the spring of 1914. Also it is rumored that metallurgical practice which is standard for the district will be used, rather than the Hybinette process, over which the company had control, and for which a treatment plant was planned. If the plans are carried out, it will be the first plant in Canada to produce metallic nickel from the ores.

The above negotiations are the ones rumored to have been backed by the Rothschilds, and to mark their entry into the activities of the western hemisphere, and the dawn of an era of contest for trade and control of the nickel market.

The American Smelting and Refining Co. did some exploratory work in the Sudbury district during the year, and made extensive examinations of properties, but later withdrew from apparent active interest.

The Cobalt district, while ranking third in the nickel production of the world, is so overshadowed by its larger neighbor, and the nickel is so secondary to the silver, that it occupies only a minor place in the consideration of the nickel industry. In this area niccolite, NiAs, occurs alone or associated with other less important nickel-bearing minerals.[1] The percentage of nickel varies for different mines, but for the whole district is probably 3 to 5 per cent. The total tonnage is small and only a minor portion of the nickel is recovered, as the oxide. The Cobalt ores are in striking contrast to the huge masses of solid ore at Sudbury, being in small, narrow, and very irregular veins.

A most promising find, aside from the Sudbury deposits, is the Alexo mine in northern Ontario. The occurrence of ore is similar to the Sudbury deposits, and is of high grade, specimens showing 5.79 to 7.08, per cent. of nickel. It is hardly likely that the field will rival the Sudbury, unless other larger deposits are uncovered. Some mining has been done, and ore shipped to Sudbury smelters.

The Kelso mine, in the Porcupine district, Ontario, contained production, and shipped a small tonnage of high-grade ore (5 per cent. Ni) to the Mond smelter. This new region is 125 miles north of Sudbury.

New Caledonia.—New Caledonia occupies second position in the ranks of producers of nickel ore, but is of very minor importance so far as the United States is concerned, as all of the product is shipped to Europe. The International Nickel Co. is reported to have some holdings in this field, but they are not being worked at present.

[1] Economic Minerals of Canada, Bull. No. 230.

The exports for the year were[1] 93,190 metric tons of nickel ore, with about 6.25 per cent. nickel, and 5893 tons of matte, with 46 to 50 per cent. nickel. The increases were 24.7 and 15.6 per cent. respectively over 1912. The total yield was approximately 10,933 tons of metallic nickel.

Lately the exportation of New Caledonian ores has been steady at about 100,000 tons per year, but there has been a great increase in the last few years in the amount smelted and shipped as matte. This is natural in view of the serious handicap of shipment half around the world, before the product can be marketed. It is only since 1911, however, that electrolytic processes have been introduced to effect this matte concentration, and to overcome the earlier failures. The New Caledonian ores are markedly different from those of Canada, in that they never contain sulphur. All are hydrated silicates, and have an apparent advantage in the absence of sulphur, and a second real one in freedom from copper. The first-mentioned advantage actually disappears, however, in view of the practice of producing matte by smelting with gypsum or other sulphur compounds. The cost of separation of copper from nickel is avoided; on the other hand, the recovered copper is an element of value in the Sudbury ores.

The production of nickel in New Caledonia is practically monopolized by two large French companies,[2] one of which has recently acquired the properties of the Consolidated Nickel Mines, Ltd., of London. The two concerns now occupy the majority of mining concessions. There are thousands of acres of rich ore-bearing lands lying idle, and likely to remain so, since the mining laws allow of land being taken up for a nominal fee. Once taken up, the lessee cannot be dispossessed as long as he pays a small annual rent, and cannot be forced to mine the ground. Thus the small owner is held out or absorbed, and the private prospector finds the expected concession already taken up. It has been suggested that a heavy tax be placed on unworked nickel lands to force the large holders to more actively work the mines leased from the government.

The Pore nickel mine was sold[3] in the early part of the year at public auction, after spirited bidding by the two rival large companies. The property has an area of 3000 acres, and brought $30,000, as against an upset price of $5000.

A French company is reported[4] to be building a hydroelectric plant in the south of New Caledonia for the production of ferro-nickel and ferro-chrome. Several thousand horse-power will be generated from one plant in 2 years, and 7600 horse-power from a second generating sta-

[1] *Eng. Min. Jour.*, Apr. 18, 1914.
[2] *Min. Jour.*, June 19, 1913.
[3] *Eng. Min. Jour.*, July 26, 1913.
[4] *Eng. Min. Jour.*, Aug. 23, 1913.

tion in 3 years. Electric smelting works will be erected near the power stations.

Other Countries.—Judged by Canadian standards, the Norwegian production and mines are small. The ore is associated with norite, thus resembling the Sudbury deposits. The output was about 29,000 tons of ore from two mines in 1912, all of the ore being smelted to matte at Evje, and then refined by the Hybinette process at Christiansand. In 1912, about 400 tons of nickel and 200 tons of copper were produced.

As reported by Coleman,[1] the ore averages 2.3 per cent. of nickel and 1.2 per cent. copper. It is smelted direct to a low-grade matte of 8 to 10 per cent. nickel plus coppr, without roasting or flux. A second smelting results in high-grade matte of 50 to 60 per cent. nickel and 32 to 20 per cent. copper. A final product of 98.70 per cent. nickel is obtained by treatment and refining of the matte by the Hybinette process.

Germany imported 6643 metric tons of nickel ore during the first half of 1913, as compared with 10,249 tons for the same period of 1912. Imports of nickel were 3416 metric tons for 1913, as against 2142 tons for 1912. Export figures were 2409 and 2555 tons for the two periods.

A new nickel field is reported[2] as Tasmania's most valuable potential possession. It was discovered 18 years ago, but there has been no exploitation in the period. Recently two companies have been at work in the Zeehan district, with apparently satisfactory results. One company has proved a lode of nickel ore for a mile and a half, and its full extent has only been partially sampled. Analyses of the ore show an average of 4 to 14 per cent. nickel and 4.3 to 6 per cent. copper. About 160 tons were recently sent to England as a trial shipment, with satisfactory results. Before further shipments are made, the ore is being roasted.

At points on the property of the second company where ore appears in large quantities, analyses have shown 5.19 to 5.6 per cent. copper and 11.95 to 13.4 per cent. nickel.

M. Bonnefond, chief of mines service for Madagasgar, reports[3] an important garnierite deposit opened up by an English company on the east coast. The average composition is 3 to 4 per cent. nickel, with a maximum of 8 per cent. At a distance of a few miles is a waterfall capable of developing 10,000 h.p. and there is a river for transport, but the seaport facilities are unfavorable.

The nickel deposits of the Urals are described by H. W. Turner.[4] Attempts were made as early as 1866 to work the deposits in the Revdinsk district, and a wet method of extracting tried, but without success. De-

[1] The Nickel Industry of Canada, Bull. No. 170.
[2] *Min. Jour.*, June 21, 1913.
[3] *Eng. Min. Jonr.* Aug. 30, 1913.
[4] *Bull. Am. Inst. Min. Eng.*, Feb., 1914.

posits have been encountered in recent years in several iron mines in the Verkline-Ufalei district, and appear to be nickeliferous pyrite derived from the serpentine mother rock, and deposited from solution in the adjoining siderite and lignite bed. Analyses showed nickel plus cobalt 1.69 per cent. in a raw sample, which contained after ignition, ash and mineral matter amounting to 22.9 per cent. of the ore, and in which there was a concentration to nickel 7.2 per cent., cobalt 0.21, gold 0.1 oz., and silver 0.50 oz. per gross ton. The ore is a carbonaceous one which can be concentrated by simple ignition to a commercial product, if the quantity is sufficient. The extent of the deposit has not as yet been determined.

An occurrence of millerite has been found in Kustamoni, Asia Minor, 60 miles from the Black Sea. It appears as narrow veins in dolomite. No work is being done on the deposit at present.

Nickel is believed to occur in fairly considerable amounts in the southwest of China. Little is known of the source, since this part of the country has only recently become possible of extensive exploration, due to the building of railways and the opening up of foreign trade. No attention seemingly has been paid to the nickel deposits, which are reported to occur at various places in Yunuan and Sau-Chuan, and are probably comparatively rich, since otherwise the Chinese could hardly have worked them by the native methods.

Nickel and cobalt minerals assaying 28.5 per cent. nickel are reported[1] in the Department of Cuzco, Peru. Lack of railroad transportation makes their exploitation unfeasible for the present.

Interest has continued in the Mayari iron ore deposits of Cuba. While these ores are not to be considered as an available source of nickel, they are of importance in a consideration of the nickel industry through resulting in a natural product similar to that furnishing one of the important outlets for metallic nickel through artificial mixture.

The Mayari range is on the north coast of Cuba,[2] about 12 miles south of the Bay of Nipe. The iron ore is a blanket deposit somewhat resembling the Mesabi range ores, and is being exploited and extensively worked by the Spanish-American Iron Co., allied with the Pennsylvania Steel Co. and the Maryland Steel Co. The deposit is generally of limonite, and covers practically an entire plateau 10 miles long by 4 miles wide. A fair average depth over 18,500 acres of explored area is 15 ft. and it is regarded as certain that there exist not less than 500,000,000 tons of ore accessible for economical mining. Analyses of several hundred samples of the natural ore gave an average nickel content

[1] *Daily Consular and Trade Reports*, Jan. 30, 1914.
[2] *Eng. Mag.*, March, 1913.

of 1.04 per cent.; other ingredients are as follows: Fe (dried)46.03, silica 5.50, alumina 10.33, Cr 1.73, P 0.015, total water 45.25. Drying and agglomeration are necessary before shipping. The Mayari pig iron will run about 1.50 per cent. nickel and 2.50 to 3.00 per cent. chromium.

Technology.—The metallurgical treatment of the Sudbury ores is as follows:[1]

(1) Roasting in heaps to remove part of the sulphur.

(2) Blast furnace smelting, producing a matte of 33 per cent. copper plus nickel; also carrying the precious metals.

(3) Matte converting in basic-lined converters, giving an 80 per cent. copper-nickel matte.

(4) Refining of the last-named matte, with separation of the nickel, copper, and precious metals.

The first three operations are carried out in the district, but the converter matte is refined in the United States or England.

At Copper Cliff limestone is used as a flux only when the blast furnaces are in poor condition, in order to lower the melting point of the slag and clean the furnace. The five furnaces are each 17 ft. long, and smelt 300 tons of roasted ore of 10 to 11 per cent. sulphur, or 400 tons of charge per day. Coke makes up 11 per cent. of the charge. Oval settlers are connected with the furnaces. The resulting first matte is about Cu 6, Ni 15, Fe 47, S 27 per cent., with a specific gravity of 4.6 to 4.8. A total of 40,000 to 45,000 tons of ore are smelted per month.

Basic converters 37 ft. long and 10 ft. in diameter blow the first matte to high grade of a composition Cu 25, Ni 55, Fe 0.5, S 19. The air pressure is 10 lb. per square inch. The converter slags are resmelted as flux. In converting, about 60 tons of matte are poured into the vessel and 5000–6000 lb. of crushed quartz are added. The slag is poured off after a 1-hr. blow, and more matte and flux added. These operations are subsequently repeated at 40-min. intervals for the entire blow of 30 to 50 hours. In the period, 300 to 400 tons of furnace matte are required, and 70 to 80 tons of high-grade matte are obtained. Accumulated flue dust and fine ores are treated in reverberatories.

A study of the reactions taking place in the roasting of copper-nickel matte has been made by E. F. Kern and M. H. Morris.[2]

British patent 18276 of Aug. 8, 1912, was granted to Gebr. Borchers,[3] covering the treatment of complex combinations of cobalt, nickel, and silver. They are first treated with alkali bisulphate at a temperature below 200° C.; then roasted at 600–700° C. in an oxidizing atmosphere. The mass is allowed to cool, is crushed if necessary, and sprayed with sulphuric

[1] *Bull.* No. 170, Canadian Dept. of Mines.
[2] *Sch. Mines Quart.*, Nov, 1913.
[3] *Eng. Min. Jour.*, Jan. 17, 1914.

acid; the treatment is repeated until the metals are sufficiently converted to a soluble form. The mass is then withdrawn from the furnace, cooled, and lixiviated. Very refractory ores are first heated one or more times with carbon at below a red heat, and in the presence of enough air to burn the carbon.

H. Pederson contributes[1] the results of studies in the simplification of the metallurgy of ferruginous sulphides of nickel and copper. A review is given of the various practices and processes.

Temiskamite, a new nickel arsenide, is described[2] by T. L. Walker.

C. R. Hayward gives the results[3] of experimental work in determining the equilibrium diagram of the system Cu_2S–Ni_2S_2. Cooling curves and photomicrographs were obtained.

O. P. Watts has compiled and summarized[4] all of the published data relating to the electrodeposition of nickel and cobalt. Electrolytes, current densities, character of deposits, and the like, are enumerated, together with a complete list of references to the original articles.

Brass with nickel added is like brass with higher copper but no nickel.[5] Other things equal, a small nickel content makes a brass easier to work cold. An improvement in the quality of brasses is effected by nickel up to 10 per cent.

Ruer and Kaneko have determined the resistivity and hardness of the alloys of nickel and cobalt.[6]

P. Weiss presents[7] some interesting observations and summaries on the magnetic properties of the alloys iron-nickel, nickel-cobalt, and cobalt-iron. Results for the three series are plotted with the strength of field at saturation and the "Curie constants" as functions of percentage composition of the alloys. The conclusions have particular bearing upon the interpretation of the constitutional relations in the different series, and upon the kinetic theory of magnetism. It is interesting to note that the strength of field at saturation at the proportions Fe_2Co is 10 per cent. higher than the value obtained for pure iron.

S. Hilpert and P. Hermann give[8] the results of an investigation of the thermoelectric properties of irreversible steels of nickel and of manganese.

Steady progress has been made in the development and utility of Monel metal, a natural alloy of about 68 per cent. nickel, and the balance copper with a few per cent. of other metals, chiefly iron. It is produced directly from a nickel-copper ore by the International Nickel Co. Its high strength, non-corrodibility, and resistance to steam have led to its use in valve seats, disks and stems, especially for superheated steam.

[1] *Metall U. Erz*, 1913.
[2] *Am. Jour. Sci.*, Feb., 1914.
[3] *Bull. Am. Inst. Min. Eng.*, Jan., 1914.
[4] *Trans. Am. Electrochem. Soc.*, 23, 99 (1913).
[5] L. Guillet, *Rev. de Met.*, 1913.
[6] Ferrum, X, 1913.
[7] *Rev. de Met.*, Dec., 1912.
[8] *Zeit. Elektrochem.*, XIX, 1913.

It finds various uses where there is exposure to salt water, and for turbine blading. It is sold under restrictions for 18 to 22 cents per pound. The greatest advance[1] of 1913 was in spreading a knowledge of the machining of the metal, and in the manufacture of drop and hammer forgings. Many castings were made for conditions of severe service, notably for the Panama Canal transmission lines, where there is abnormal atmospheric corrosion.

The average properties of rolled rods are—tensile strength 88,232 lb. yield point 55,587, elongation 42 per cent. in 2 in. Besides castings of various kinds up to 25,000 lb. weight, the metal can now be obtained from stock in numerous sizes and shapes of rolled sections, and as wire, wire cloth, etc.

Cobalt

Although the development of cobalt bearing steels and alloys has attracted great attention during the year, and without doubt has increased the demand for the metal, the United States remains in practically the same position as for some years past. There was no production of cobalt ores, and no material development in their exploitation. And so far as known, there was no production of the metal, and whatever oxide was produced was from imported ores. The International Nickel Co. has not produced any cobalt for a couple of years. The statistics of importations are included in the table giving the figures for nickel.

The tariff changes on cobalt products as effected by the new Underwood act of Oct. 3, 1913, as as follows:

	Old	New
Cobalt oxide	25 cents per lb.	10 cents per lb.
Cobalt metal	Free.	Free.
Cobalt ore	Free.	Free.
Cobalt alloy steel	7/40 to 7 cents per lb., according to value, and 20 per cent. above 40 cents per lb.	15 per cent. adv.

The most important development of the year, other than the commercial progress in the cobalt steels, has been the presentation of the first results of the investigation of this metal, instituted by the Canadian Department of Mines in 1912, and carried out under the direction of Dr. H. T. Kalmus, who has been investigating cobalt and its alloys for several years.

In the sixteenth to eighteenth centuries,[2] blue cobalt, or cobalt smalt, with about 6 per cent. cobalt, was produced in Saxony and Bohemia on a commerical scale, and a rapidly increasing industry was developed. In 1792, about 3000 tons of smalt were put out per year, but the production declined, and at the present time the silver and cobalt have become of negligible importance in the districts. Up to 1904–05, New Caledonia,

[1] W. E. Oakley, *Metal Industry*, Jan., 1914.
[2] H. T. Kalmus, *Met. Chem. Eng.*, Mar. 1914, p. 184.

New South Wales, Chili, Spain, Norway, and Prussia supplied the world with cobalt, with the first named having a practical monopoly in the production of 80 to 90 per cent. of the entire supply. The ores were shipped to Europe for treatment.

Production at the silver-cobalt mines of the Cobalt district of Ontario began in 1904, and since that time they have obtained the monopoly in cobalt production.

Previous to the discovery of the now famous ore deposits of the Cobalt district,[1] the metal cobalt had already been noted as a constituent of the Sudbury nickel-copper deposits; in fact a small recovery was reported from 1892 to 1894.

The silver-cobalt-nickel ores of the Cobalt district are, almost without exception, mined primarily for their silver contents. The cobalt is a by-product for which the mine owners now receive no return whatever, a curious fact in view of the circumstance that these ores have displaced almost all others in supplying the world with cobalt.

Cobalt has been recovered as cobalt oxide or cobaltic material containing nickel or nickel oxide and a little silver, in Canadian smelters at Copper Cliff, Deloro, Thorold, Orillia, and North Bay. It is possible that recovery is also being made outside of Canada, at plants to which Cobalt ore has been shipped. The production has been sufficient to cause a falling off in the price of cobalt oxide from $2.50 per pound in 1907, to less than a dollar in 1911. It is estimated that about 825 tons of metallic cobalt were contained in the ores shipped from the camp in 1911. About 21.5 tons of metals were recovered in Canadina smelters, contained in cobalt oxide, and 119 tons contained in crude cobalt material.

The silver refineries at Thorold and Deloro now practically[2] control the world's trade in cobalt oxide, since Copper Cliff shut down and Orillia burnt. The Ontario government pays a bounty of 6 cents per pound on the metallic contents of refined cobalt oxide and nickel oxide. These were produced during 1913 to the value of $385,000. Three companies were paid $10,000 in bounties for the year. The bounty is provided for to 1917. No claims have as yet been made for bounties on other than cobalt oxide.

In the Ontario district the more important ores[3] are native silver, smaltite ($CoAs_2$), niccolite (NiAs), and chloanthite ($NiAs_2$), associated with which are usually found some dyscrasite (Ag_6Sb), argentite (Ag_2S), pyrargyrite (Ag_2SbS_3), cobalt bloom ($Co_3As_2O_8 + 8H_2O$), and nickel bloom ($Ni_3As_2O_8 + 8H_2O$). Cobalt is 330 miles north of Toronto, and the district centers about the town and within very few miles of it. The ore

[1] Economic Minerals of Canada, No. 230.
[2] T. W. Gibson, *Eng. Min. Jour.*, Jan. 10, 1914.
[3] H. T. Kalmus, *Met. Chem. Eng.*, Mar., 1914, p. 1840.

deposits are in pre-Cambrian rocks,[1] and while they differ greatly as regards form and mineral content, it is believed that all owe their origin to igneous intrusion. The ores are essentially arsenides of cobalt and nickel with native silver. They are believed to be directly connected with intrusions of igneous rocks, and are the end product of diabase intrusions, deposition having taken place from aqueous solution.

The Cobalt silver deposits are not known to extend to a greater depth than 200 ft. below the soil. The veins are numerous, and are approximately perpendicular, varying in width from a mere crack to 12 in. or more, with values at times as milling ore in the adjacent wall rock.

The market for cobalt ores[2] was improved by the decision of one of the American smelters to recommence treatment. The action of the American Smelting and Refining Co. in putting a 7 per cent. arsenic limit on cobalt ore has been responsible for curtailing the market, as a proportion of the ores from the Cobalt Camp are in excess of this limit.

The metallurgical processes at the several plants in the Cobalt field are described by Arthur A. Cole.[3] The ores are treated by combined amalgamation and cyanidation.

H. A. Megraw says[4] that nickel and cobalt combinations in ores have generally been considered difficult to treat, but that they are being successfully cyanided at the present time. They are undoubtedly of detriment in the solution, as they consume cyanide, but the consumption has not been so great in the Sudbury district as to prohibit successful work. Silver bearing ores with nickel, cobalt, manganese, and many other elements are being successfully cyanided.

Dr. Kalmus states[5] that until recently about one-half of the cobalt residues found its way to the United States, and the cobalt content has never been recovered to any extent. Practically the only way in which the cobalt found its way into the industries was as cobalt oxide, Co_3O_4, for use as coloring. The production in Ontario has much exceeded the consumption, roughly three to one until the past year, when demand has increased. As a rough estimate, 1000 tons of cobalt metal per year may be taken as the present cobalt output of the Ontario mines.

The researches undertaken for the Canadian government will probably be finished during 1914, the following covering the scope and subdivisions of the work. The report of Section I is off the press.

I—Preparation of metallic cobalt by reduction of the oxide.
II—A study of the physical properties of the metal cobalt.
III—Electroplating of cobalt and its alloys.
IV—Cobalt alloys of extreme hardness.
V—Cobalt alloys with non-corrosive properties.
VI—Cobalt steels.

[1] Willis and Knight, *Eng. Min. Jour.*, June 7, 1913.
[2] *Eng. Min. Jour.*, Dec. 6, 1913.
[3] *Can. Min. Jour.*, Dec., 1913.
[4] *Eng. Min. Jour.*, Oct. 4, 1913.
[5] *Met. Chem. Eng.* Mar., 1914, p. 184.

Some important facts derived from the investigation are:

(1) The preparation of the black cobalt oxide, Co_3O_4, from Ontario cobalt-silver ores, has been worked out and is at present extensively practised at the Canadian smelters; therefore, this oxide was taken as the raw material for these investigations.

(2) Metallic cobalt, of a very high degree of purity, may be made from this oxide by reduction with carbon, with carbon monoxide gas, with hydrogen gas, or with aluminium; the former three at such temperatures as to make it commercially attractive and economical.

(3) Metallic cobalt is not so closely identical with nickel in its properties as has been commonly considered.

(4) Cobalt is considerably harder than nickel, being about 125 on the Brinell scale of hardness, whereas nickel is about 65 on the same scale.

(5) Cobalt up to about 15 per cent., alloyed with steel containing small percentages of chromium and tungsten or molybdenum, yields alloys of extreme hardness, and of superior cutting qualities when used as high speed tool steels. Nickel substituted for cobalt in these alloys does not in any case give the same results.

(6) The melting point of pure cobalt we find to be 1467° C., to within 5°, whereas that of nickel is 1435° C. Therefore, so far as its melting point is concerned cobalt is not very much more difficult than nickel to alloy.

(7) Pure cobalt has a higher tensile and compressive strength than any of the pure metals with which the writer is familiar. The effect of cobalt on the tensile and compressive strength of certain alloys and steels is being studied.

(8) Cobalt is magnetic at all temperatures up to about 1110° C. We have found an alloy of cobalt and iron, approximately Fe_2Co, which has a magnetic permeability in strong magnetic fields about 10 per cent. higher than the best Swedish soft iron. This has been independently discovered at this laboratory and by P. Weiss, Zurich, Switzerland.

(9) Cobalt alloys with chromium, and the resulting cochrome may be swaged to form wires which are in some respects superior to nichrome wires as heating elements; they are less readily oxidized at high temperatures, and have a higher melting point. The thermoelectric properties of cochrome are being studied.

(10) Small percentages of cobalt added to pure iron give alloys which are extremely non-corrosive and which will probably find extended use as sheet roofing materials. These are at present being tested on a commercial scale.

(11) Cobalt when electroplated on steel and brass gives a more adhesive plate with a more silvery appearance than nickel. It seems to

be less readily corroded than nickel under ordinary atmospheric conditions and upon handling.

(12) Cobalt will probably find extended use in the plating industries for special purposes, even at a much higher price than nickel, in that it may be plated with extreme satisfaction from a more concentratedsolution than nickel, and at a much higher current density. Cobalt can be deposited several times as rapidly as nickel.

The melting point of cobalt of 99.95 purity has been determined by the Bureau of Standards[1] as $1478 \pm 1°$ C. This is several degrees higher than the determination of Kalmus.

Alloys of cobalt 40, tin 60, are very acid proof,[2] even to aqua regia but are too brittle for practical use. By alloying 5 to 20 per cent. of this Co-Sn alloy with copper, a product is obtained which can be machined, and still retains a high degree of non-corrodibility. The alloys are best prepared by dissolving the Co-Sn alloy in molten copper.

Very considerable headway has been made in introducing and developing cobalt tool steels. These are in general of usual high speed composition, with the addition of several per cent. of cobalt.

The German patent office has granted[3] without restriction, a full patent to the Becker Steel Works, relating to the manufacture of high speed steels with cobalt up to 15 per cent. in addition to the usual chromium, tungsten, molybdenum, vanadium, etc. The principal continental manufacturers opposed the patent but were overruled. Patents were also granted in Great Britain. The cost is stated to be higher than for the usual steels.

G. Schlesinger reports[4] the progress of German steel works in the production of high speed steels, dealing principally with development and comparative tests of the cobalt tool steels. A typical cobalt steel has 0.76 carbon, 5.03 cobalt, 4.38 chromium, and 16.40 tungsten. The above cobalt is stated to be rather high. Cutting tests on mild and chrome-nickel steels, and on cast iron, showed an increased life in the cobalt steel as compared with high speed steels, of three to five times. Computing the efficiency values by dividing the endurance figures by the price, the relative values in two tests were 41 to 8, and 111 to 24, in favor of the cobalt material.

Schlesinger's results have been criticised in England on the ground that his treatments were not such as to bring out the highest efficiencies of the cobalt-free steels. Some earlier British tests did not show striking superiority of the cobalt bearing steels, although there was some improvement over ordinary high speed steels.

[1] Reprint 205.
[2] *Iron Age*, Aug. 28, 1913.
[3] *Iron Age*, Feb. 12, 1914.
[4] *Stahl u. Eisen*, June 5, 1913.

COLE, A. A.—Smelting the Cobalt Silver Ores. *Can. Min. Jour.*, Dec. 1, 1913.

COLEMAN, A. P.—The Nickel Deposits of the Sudbury District, Ontario. *Can. Min. Jour.*, Sept. 1, 1913, p. 552.

COLEMAN, A. P.—The Nickel Industry: With Special Reference to the Sudbury Region, Ontario., Can. Dept. of Mines. *Bull.* 170; *Min. Sci. Pr.*, Sept. 13, 1913, p. 412.

GRAY, ALEX.—Canada's Nickel Industry. *Can. Min. Jour.*, Oct. 1, 1913.

GUILLET, L.—Transformation Points of Nickel-Chromium Steel. *Compt. rendus*, CLVI, 1913.

HAMILTON, D. T.—Stellite as a Cutting Tool. *Machinery*, Dec., 1913.

HAYNES, ELWOOD.—Alloys of Cobalt with Chromium and Other Metals. *Bull. Am. Inst. Min. Eng.*, Feb., 1913.

HAYNES, ELWOOD.—Chrom-Nickel und Chrom-Kobalt-Legierungen. *Sudwestdeutsche Industriezig.*, May 17, 1913, p. 295.

HIRSHBERG, L. K.—Composition and Uses of German Silver. *Min. Eng. World*, March 29, 1913, p. 624.

HORE, R. E.—Characteristics of the Cobalt Silver Ores, Ontario. *Can. Min. Jour.*, Dec. 15, 1912, p. 851.

HORE, R. E.—Magnetic Origin of Sudbury Nickel-Copper Deposits. *Can. Min. Jour.*, July 15, 1913.

HORE, R. E.—Sudbury Nickel-Copper Industry. *Mines & Minerals*, Feb., 1913.

KALMUS, H. T.—Preliminary Experiments on the Metal Cobalt and Its Alloys. *Can. Min. Inst.*, March 5, 1913.

KALMUS, H. T.—Preparation of Metallic Cobalt by Reduction of the Oxide. Can. Dept. of Mines, *Bull.* 259.

KALMUS, H. T.—The Metal Cobalt and Its Alloys. *Can. Min. Jour.*, Dec. 15, 1914.

LALANDE, DE.—Le Nickel en 1912. From *L'Echo des Mines. Bull. du Commerce*, April 12, 1913, p. 15.

MILLER, W. G.—The Cobalt Area. *Can. Min. Jour.*, Sept. 1, 1913.

POIZAT, C. DU.—La Nouvelle-Caledonie Miniere et Metallurgique en 1912. *L'Echo des Mines*, April 10, 1913, p. 418.

STEPHAN, M.—Production of Copper and Nickel in the Electric Furnace. *Met. Chem. Eng.*, Jan., 1913.

THOMAS, KIRBY.—The Sudbury Nickel District of Ontario. *Eng. Min. Jour.*, Jan. 10, 1914.

VAN HORN, FRANK R.—A New Occurrence of Silver, Copper, and Cobalt Minerals in Mexico. *Am. Jour. Sci.*, Jan. 1912, p. 23.

WATTS, OLIVER P.—The Electrodeposition of Cobalt and Nickel. *Trans. Am. Electrochem. Soc.*, **23**, 53, 1913.

WILSON, M. E.—Origin of the Cobalt Series. *Jour. of Geol.*, XXI, No. 2.

————. Monel Method of Separating Nickel and Copper Sulphides. *Can. Min. Jour.*, Feb. 1, 1914.

————. Nickel Developments at Sudbury, Ontario. *Eng. Min. Jour.*, Aug. 2, 1913, p. 205.

————. Nickel in South Africa. *So. Afr. Min. Jour.*, Aug. 16, 1913, p. 642.

————. Sorting, Roasting, and Smelting Nickel-Copper Ore, Canadian Copper Co. *Can. Min. Jour.*, Aug. 1, 1913.

————. The Metallurgy of Sudbury Copper-Nickel Ores. *Met. Chem. Eng.*, Nov., 1913.

PETROLEUM AND NATURAL GAS

By W. G. Matteson

The remarkable increase in the petroleum output of the United States that has been going on for the last 10 or 15 years was again maintained in 1913, with the sufficient margin to make up for the comparatively small increase that was shown in 1912. The petroleum production of the country has more than doubled during the past 10 years. As is shown by the accompanying chart, this progress has been remarkably uniform, with only one decrease in yield during the time in question, and this was followed by a recovery in the following year that was sufficient to maintain the average rate of increase.

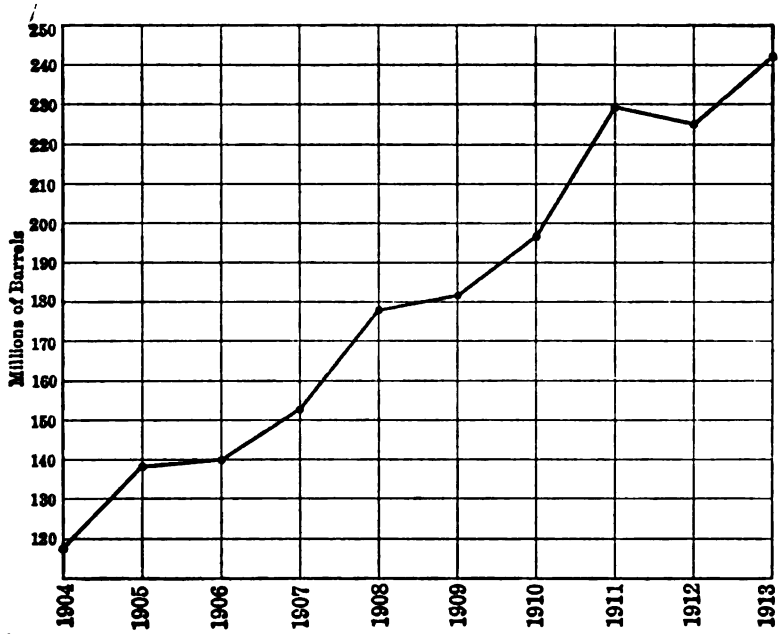


Fig. 1.—Petroleum Production for Ten Years.

The production for 1913 amounted to 243,870,985 bbl., an increase of 21,757,767 bbl. over 1912. This increase comes from an increase of about 13,000,000 bbl. in California and a similar increase in the Mid-continent field, with a smaller increase of about 3,000,000 bbl. in the Gulf field. This is reduced to the given figures by reductions, principally in Illinois and the Pennsylvania field.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES.
(In barrels of 42 gal.)

Field.	1907	1908	1909	1910	1911	1912	1913(b)
California (a)	40,085,000	45,000,000	58,250,300	74,227,150	81,134,391	86,450,767	97,764,525
Colorado	400,000	411,536	(b) 310,771	(b) 289,794	226,936	206,052	188,799
Gulf { Texas	12,350,000	11,206,464	9,256,000	8,181,580	9,526,474	11,735,057	15,009,478
Gulf { Louisiana	4,620,000	6,835,130	3,220,000	(b) 6,841,395	10,730,430	9,263,439	12,498,828
Illinois	24,540,024	33,685,106	30,898,339	(b)33,143,362	31,317,038	28,601,308	23,893,899
Lima { Indiana. }	8,080,000	7,287,000	6,192,000	5,171,000	6,231,164	(f) 4,925,906	956,095
Lima { Ohio. }							3,817,043
Mid-Continental(c)	47,556,906	48,274,782	48,007,267	53,613,080	57,348,456	53,019,867	65,954,413
Ky.-Tennessee	1,250,000	1,350,000	(b) 639,016	(b) 468,774	472,458	484,368	534,568
Pennsylvania (d)	25,500,000	24,940,000	25,394,200	26,089,900	23,277,374	25,854,148	25,397,217
Wyoming	13,000	(e) 13,000	(b) 22,137	(b) 115,420	186,695	1,572,306	2,406,522
Others	3,000	(e) 3,000	(e) 5,000	(e) 5,000	8,000	*Nil.*	34,843
Total	164,347,930	178,203,345	182,205,030	208,196,415	220,449,396	222,113,218	248,446,230

(a) Reported by the California Producers' Association, except the statistics for 1907 and subsequent years, which are of our own collection. (b) Statistics of the U. S. Geological Survey. (c) Kansas and Oklahoma. Includes production from North Texas, in 1910. (d) Pennsylvania, New York, West Virginia, Eastern Ohio. (e) Estimated. (f) Includes Michigan.

Imports and Exports.—Imports of crude oil into the United States in 1913 amounted to 713,100,321 gal., valued at $10,944,780 compared with 290,280,000 gal., valued at $4,677,174 in 1912. Imports of refined oil, mainly benzine, amounted to 18,261,202 gal., valued at $2,052,231 compared with 19,486,050 gal., valued at $1,356,057 in 1912.

The world-wide increased demand for crude and refined oil is reflected in the quantities of such products exported from the United States in 1913. More significant perhaps is the value of such exports, which surpassed all previous years. Fifty-two per cent. of the crude petroleum exported was sent to Canada. The total quantity of gasoline exported was 117,728,286 gal. valued at $17,418,777 or 14.79 cents per gallon. Of this amount

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (a)
(In Thousands of Gallons and Thousands of Dollars.)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating.		Residuum.		Totals	
1899	117,690	$5,958	18,210	$1,597	733,382	$49,172	71,116	$8,658	(b)21,609	$658	962,007	$66,043
1900	133,161	7,341	18,570	1,681	739,163	54,693	71,211	9,933	(b)19,750	845	986,855	74,493
1901	127,008	6,038	21,685	1,742	827,479	53,491	75,306	10,260	(b)27,596	1,255	1,079,059	72,786
1902	145,234	6,331	19,683	1,393	778,801	49,079	82,200	10,872	(b)38,316	922	1,064,234	68,597
1903	126,512	6,782	12,973	1,519	691,837	51,356	95,622	12,690	(b) 9,753	282	936,697	72,629
1904	111,176	6,351	24,989	2,322	761,358	58,384	89,738	12,389	34,904	1,174	1,022,165	80,620
1905	126,185	6,086	28,420	2,215	881,450	54,901	113,730	14,312	70,728	2,128	1,220,513	79,641
1906	148,045	7,731	27,545	2,488	878,274	54,858	151,269	18,690	64,645	1,971	1,269,788	85,738
1907	126,306	6,334	34,625	3,676	905,924	59,635	152,029	19,210	75,775	2,528	1,294,660	91,383
1908	149,190	6,520	43,890	4,542	1,129,005	75,988	147,769	18,971	77,552	2,793	1,547,405	108,815
1909	170,338	6,028	68,759	5,800	1,046,401	67,814	161,640	20,018	121,966	4,180	1,569,103	103,829
1910	180,111	5,404	100,695	8,407	940,247	55,642	163,832	20,921	117,605	3,732	1,502,491	94,107
1911	201,843	6,165	137,295	11,483	1,112,295	61,055	183,320	23,337	133,979	3,882	1,768,732	105,923
1912	188,711	6,770	186,000	20,459	1,026,138	62,084	216,393	28,297	266,237	6,599	1,883,480	124,210
1913	194,470	8,448	188,051	28,092	1,119,441	72,042	207,639	29,608	426,859	11,125	2,136,466	149,316

(a) In addition to the above, the following quantities of paraffin and paraffin wax were exported (1 = 1000): 1898, 166,317 lb. ($6,363); 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186); 1901, 151,695 lb. ($7,960); 1902, 175,268 lb. ($8,398); 1903, 204,120 lb. ($9,596); 1904, 174,582 lb. ($8,273); 1905, 160,836 lb. ($7,873); 1906, 173,504 lb. ($8,463); 1907, 207,504 lb. ($10,209); 1908, 141,667 lb. ($6,923); 1909, 181,328 lb. ($7,609); 1910, 199,913 lb. ($7,329); 1911, 214,018 lb. ($7,048); 1912 294,591 lb. ($9,603). 1913, 236,046 lb. ($8,177). (b) Reported in 1,000 bbl. of 42 gal.

44,543,990 gal. were delivered to European ports and 37,509,535 gal. to Canada. Exports in lubricating oils showed a slight decrease as compared with 1912; owing to the general advance in prices, however, the value of the quantity exported exceeds that for any single previous year. The exports are shown in the above table:

PETROLEUM IN THE UNITED STATES

California.—California nearly reached the 100,000,000-bbl. mark in 1913, the total production being 97,764,525 bbl., valued at $45,661,400, which is an increase of 10,491,932 bbl. (12 per cent.) and $6,036,899 respectively over 1912. The output of the various fields and the well record for the year, as quoted by the *Oil City Derrick* from the *Standard Oil Bulletin* follows:

Field.	Production.		Rigs Compl. during Year.	Wells.	
	Year.	Per Day.		Completed.	Ab'd.
Kern River	9,980,940	27,345	31	33	1
McKittrick	4,496,842	12,320	59	18	6
Midway-Sunset	39,024,780	106,917	248	241	25
Lost Hills-Belridge	5,274,553	14,451	93	111	6
Coalinga	18,604,626	50,972	54	64	20
Lompoc-Santa Maria	5,817,711	15,939	12	16	3
Ventura Co.-Newhall	1,022,052	2,800	56	37	4
Los Angeles-Salt Lake	2,898,846	7,942	12	17	25
Whittier-Fullerton	10,657,053	29,197	57	36	2
Summerland	62,406	171	.....	.....	4
Watsonville	27,375	75	.....	2	1
Total	97,867,184	268,129	622	575	97

Stocks on hand December 31, 1913..... 47,870,177 bbl.
Stocks on hand December 31, 1912..... 47,552,392 bbl.

The slight increase in stocks shows that the consumption of crude was practically equivalent to the production and for the first time in the history of the oil industry in the state, the records show a year when the production of heavy oil has not exceeded that of oil of 20° gravity or lighter. Prices remained stationary or moved within narrow limits. Oil of a minimum gravity of 14° Bé. brought $0.40 a barrel but $1.10 was paid for some of the Ventura County oil of 33° and lighter. The total value of all the petroleum produced during the year will average between $0.46 and $0.49 per barrel.

The gain in production made by California is significant when the many unfavorable market features are considered. The most adverse influences were the restrictions placed on the heavy gravity oil by the Standard Oil Co. and the low prices paid for such product which resulted in a very restricted market. Near the close of the year, the

Standard Co. resumed the purchase of heavy gravity crude in large quantities which policy was adopted at once by other refineries. This satisfactory condition promises to result in an improved market for low-grade oil in 1914 and another substantial increase in California production may therefore be expected.

The increased yield of the lighter oils is reflected in the production of the Midway, Fullerton, Lost Hills, and Ventura fields whereas Coalinga, Kern River, Santa Maria and the heavy oil districts showed substantial losses when compared with their yields for 1912.

A comparison of the well records for the last 3 years reflects the various market influences that have combined of late to restrict drilling in certain fields. In 1911, 970 wells were completed and 246 abandoned; 1912 resulted in 776 completions and 402 abandoned, whereas 1913 gave only 575 completions and 97 wells abandoned. This markedly lessened activity in drilling operations during 1913, with a decrease in completions of nearly 50 per cent. as compared with 1911, is due largely to the suspension of operations in the heavy oil districts where many properties closed down entirely pending a more favorable market for their product. The completions of these districts for the last 3 years are as follows:

Field.	1911.	1912.	1913.
Coalinga	192	142	64
Kern River	153	94	33
Lompoc-Santa Maria	19	23	16
Total	364	259	113

The successful wells of 1913 were phenomenal gushers and such are largely responsible for the increased production of the state. The Fullerton field yielded large producers with such frequent regularity as to justify the attempts to reach the unusually great depth of the oil sands. The press bulletin issued by the U. S. Geological Survey states that "the 'west side' fields of Kern County continued as strong factors in the increasing output of the State, and the Buena Vista Hills, Elk Hills, and other new districts gained in interest. Even the comparatively old Kern River area near Bakersfield sustained interest by 'wildcatting' to the northwest where the Standard Oil Co.'s well went into oil and aroused geological and financial speculation over a large area.

"Coalinga had many eventful features, including extensions of territory to the east and the discovery of additional deep sands yielding oils containing paraffine.

"The Santa Maria field benefited by increased technologic development by which oils were topped and dehydrated with markedly greater efficiency. These developments included the successful introduction of the Cottrell electric dehydration process. The adoption of the Trumble and Dyer topping and dehydration processes and the great

advance in methods of obtaining gasoline from natural gas were among the striking achievements of the year, but while less spectacular, the economies effected by the minor improvements in the great refineries at Port Richmond, Oleum, and El Segundo contributed perhaps equally to the general problem of efficient refining.

"In transportation the new pipe line of the General Petroleum Co. over Tehachapi Pass effected cheaper transportation to the south, and the natural gas line to Los Angeles was equally advantageous. Meanwhile several new tank oil carriers and oil-burning steamships were added to the Pacific coast trade and aided in increasing consumption.

"The asphalt branch of the oil industry is claiming growing attention and it is likely that a large amount of the surplus heavy oil will be utilized in the manufacture of asphaltic products. The Standard placed three 1200-bbl. stills in action in the asphalt department of the El Segundo refinery, and two more are to be constructed. Three similar stills have also been installed at the new Kern River refinery. The Standard has developed a market for asphaltic products in the eastern United States.

"Heavy investments of English capital in oil properties formed one of the most striking features of the year.

"American capital was also very active, the Standard, Union, and numerous other corporations acquiring various properties in all the important fields. Withdrawals of large areas of rich lands by the government, and prosecution of companies alleged to be operating on government land seriously handicapped activities in some of the more important districts, and developed a feeling of uncertainty.

"On account of the increased cost of fuel oil for battleships and the fact that foreign corporations are rapidly purchasing reserves of oil in the United States, the Secretary of the Navy has recommended to Congress the policy of producing crude oil from the naval reserves and obtaining fuel oil from it. The lands that are apparently in view for government exploitation are in Oklahoma and California with a possibility of some in Alaska.[1] The time is not ripe for any recommendations for producing in California. The titles of lands in the navy petroleum reserves are not clear, and the outcome of the suits for the recovery of the lands therein from the Southern Pacific cannot be foreseen. Moreover the status of the lands will be influenced by the final decision in the Mid-West Oil Co.'s case, which will determine the status of claims at the date of the order of withdrawal from entry of these lands."

Colorado (By R. D. George).—The two oil-producing areas in Colorado, namely, the Florence field in Fremont County and the Boulder field in Boulder County, experienced a marked decline in the output for

[1] *Eng. Min. Jour.*, Jan. 31, 1914.

1913. The total production for the year is 188,799 bbl. valued at $174,799 as compared with 206,052 bbl. valued at $199,661 in 1912, a decrease of 17,253 bbl. or 8.4 per cent. The Boulder field continued the alarming decline which began in 1912, the yield from this area being 8,341 bbl. as compared with 15,304 bbl. for the previous year, a decrease of 45 per cent.

The production and value of petroleum in Colorado from 1903 to 1912 inclusive is as follows:

Year.	Boulder.		Florence.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1903[1]	36,722	.....	447,203	.....	483,925	$431,723
1904[1]	18,167	$20,034	483,596	$558,001	501,763	578,035
1905[1]	10,502	11,502	365,736	326,104	376,238	337,606
1906[1]	48,952	53,847	278,630	208,828	327,582	262,675
1907[1]	68,353	75,188	263,498	197,625	331,851	272,813
1908[1]	84,174	124,794	295,479	221,609	379,653	346,403
1909[1]	85,709	129,812	225,062	187,900	(a)310,861	318,162
1910[1]	42,186	63,420	193,482	174,332	(b)239,794	243,402
1911[1]	37,973	50,393	187,341	175,763	(b)226,926	228,104
1912[1]	15,304	19,130	190,498	180,281	(c)206,052	199,661
1913	8,341	10,426	160,304	142,782	168,645	153,208

[1] Statistics 1903–1912 from Mineral Resources of U. S., 1912.
(a) Includes a small production in Garfield County. (b) Includes production of Garfield and Rio Blanco Counties. (c) Includes production of Rio Blanco County.

Sixteen wells were drilled in the producing fields during 1913 of which twelve were dry and four yielded oil. Such results are very significant and indicate that Colorado must depend on the development of new areas in the future to sustain her production of past years. The Rangely field in Rio Blanco County has been developed to a considerable extent, but is not a producer. It is difficult to obtain facts regarding the conditions in this field, but current reports indicate that about one hundred wells have been drilled, a considerable majority of which found oil in what appeared to be commercial quantities. Owing to the distance from transportation and the lack of facilities for refining, the wells were capped immediately after oil was discovered and nothing of importance has been done for some time.

As a result of the successful development of oil in Wyoming, there has been a considerably increased activity in prospecting in Colorado during the past year, and many parts of the state have been boomed as prospective oil fields. Among these may be mentioned the DeBeque area in Mesa County where several wells were drilled a number of years ago. Most of these wells found oil in small quantities and considerable quantities of gas. During the year 1913, there was revival of activity in this field, several companies prepared to drill, and two of these began active

operations. It is reported that a promising quantity of oil and considerable gas were found in one of the wells. Mr. E. G. Woodruff, a government geologist who has made a report on the district, has concluded that only a few square miles in the vicinity of DeBeque are possibly oil bearing.

Drilling has also been carried on at Aurora, a short distance east of Denver in Arapahoe County, near Morrison in Jefferson County, at Falcon, northeast of Colorado Springs in El Paso County, and south of Lamar in Prowers County, but up to the present time none of the borings have been successful.

Illinois (By Raymond S. Blatchley[1]).—Illinois continued in 1913 the alarming decline in oil production that threatens to speedily reduce her rank as a producing state. The estimated production for the year is 23,893,899 bbl., as against 28,601,308 in 1912. The accompanying table covers the annual production from 1905 to 1913:

ILLINOIS OIL PRODUCTION, 1905–1913.[2]

Year.	Barrels.	Value.
Previous	6,576	.....
1905	181,084	$116,561
1906	4,397,050	3,274,818
1907	24,281,973	16,432,947
1908	33,686,238	22,649,561
1909	30,898,339	19,788,864
1910	33,143,262	19,669,383
1911	31,317,038	19,734,339
1912	28,601,308	24,332,605
1913	23,893,899	27,432,000
Total	210,406,767	$153,431,078

It may be expected that such a sharp decline will continue for some time or until the general production reaches a stage which will correspond to the development of the deep-sand locality of Lawrence County. Here the numerous pools have a good staying quality and therefore their decline may be expected to be slow. The opening of new pools is liable, of course, to reverse the situation. The basis of estimating the production for 1913 is to assume the tank car shipments at 2,000,000 bbl. as compared with 2,674,649 bbl. for 1912 and to add this amount to the pipe-line runs of the Ohio Oil Co. and the Tidewater Pipe-line Co. The tank car shipments were made from Duncansville, Lawrenceville, Flat Rock, Stoy, Robinson, Bridgeport, Sandoval, Carlyle, Casey, and Allendale. The accompanying table gives the pipe-line runs and stocks, by months, of the Ohio Oil Co. and the Tidewater Pipe-line Co., according to the *Oil City Derrick:*

[1] *Eng. Min. Jour.*, Jan. 17, 1914.
[2] Day, Mineral Resources of the U. S., Calender year 1912, Advance chapter, 1913, p. 12.

ILLINOIS OIL PRODUCTION FOR 1913.

Month.	Runs, Bbl.		
	Ohio Oil Co.	Tidewater Pipe-line Co.	Stocks, Bbl., Ohio Oil Co.
January	1,614,667.45	126,944.68	11,598,519
February	1,366,718.50	112,266.29	10,366,955
March	1,478,900.43	124,473.25	9,966,083
April	1,479,791.92	126,079.22	9,486,416
May	1,573,150.55	145,629.14	8,990,143
June	1,493,690.77	128,682.11	8,111,629
July	1,557,197.98	136,618.21	7,618,891
August	1,506,112.05	136,306.20	6,934,310
September	1,469,552.16	141,854.13	6,478,499
October	1,515,010.47	147,261.93	5,782,397
November	1,407,188.83	131,882.68	5,875,837
December	1,471,546.98	120,996.32	5,613,373
Total	17,933,528.10	1,578,994.16	

The decline of production, like that of 1912, is further marked by the release of oil from storage. Surplus oil began to accumulate from 1906 and reached its zenith about September 1, 1910, with stocks aggregating 29,289,164 bbl. The drain on storage continued steadily until August 1, 1912, at the rate of about 19,500 bbl. per day. From August, 1912, until Feb. 1, 1913, the drain averaged 23,400 bbl. per day and since that time it has averaged about 16,000 bbl. per day.

Illinois has shared steadily in the general advance in prices of oil since Jan. 1, 1912. This has been due chiefly to the demand for motor fuels and also other prevailing economic conditions. The highest annual value of oil in the state was reached in 1913. The following table shows the advances in price of Illinois oil.

FLUCTUATIONS IN PRICES PER BBL., OF ILLINOIS OIL IN 1913.

Date.	Price per Bbl.	Date.	Price per Bbl.
Jan. 1	$1.08	Feb. 20	$1.25
Jan. 3	1.11	Apr. 15	1.30
Jan. 27	1.14	Nov. 5	1.35
Feb. 1	1.17	Nov. 19	1.40
Feb. 6	1.20	Nov. 21	1.45

The average price per barrel for the 11 months is about $1.27, which makes the total value of oil produced for the year about $27,432,000.

The main oil fields of southeastern Illinois showed a general decline for the year. The Clark, Cumberland, Coles and Edgar County fields (shallow pools) show a much more weakened condition than in the previous year. These fields produce from 1 to 3 bbl. of oil per day per well and still seem to be profitable when a number of them are pumped on one central power. The Crawford County area maintained the same steady low yield of the year before. There was but little new drilling done in the country.

The chief inside development in the main fields took place in Lawrence

County, particularly at the south end of the field where there are as many as four and often five producing sands to the well. Even this new work was greatly handicapped because of an extensive summer drought which caused a shortage of water for drilling purposes. The new wells were of good size but not sufficient to check a general decline for Lawrence County and hence for Illinois. The wonderful production of the area has delayed the decline of the State production for several years. Most of the new drilling was done to the McClosky limestone.

The Allendale pool was discovered and defined in 1912, in sections 3, 4, 9 and 10 of T. 1 N., R. 12 W., Wabash County. This pool was a disappointment in extensive development. There are at present 36 producing wells with a daily production of about 700 bbl. The oil comes from a depth of 1480 to 1550 ft. in a sand which seems to correspond to the Kirkwood sand of Lawrence County. The field structure has the appearance of an isolated shelf along the western limb of the LaSalle anticline, along which the main fields lie.

The Carlyle pool, three miles northwest of Carlyle, Ill., showed a decline in production in the last year. There are at present 154 producing wells in the field with an average daily production of about 1070 bbl. Only 10 new wells were added to the field during the year. These had an initial yield of 96 bbl.

The Sandoval pool, just north of Sandoval, has 112 producing wells with an average daily production of about 875 bbl. The new drilling in this field exceeded that of Carlyle. There were 17 new wells developed with an initial production of 405 bbl.

Three new oil wells were added to the Carlinville pool in Macoupin County. One of the wells is credited with an initial yield of 100 bbl., of a thick heavy oil while the total initial yield of the three reached 165 bbl. There are now six gas wells and seven small oil wells in the field. The oil comes from the Pottsville sand immediately overlying the St. Louis limestone.

A small oil well was discovered a mile south of the old Brown well east of Centralia, Ill. The initial yield of the well was 20 bbl. The oil comes from a depth of about 1650 ft. in a sand which corresponds to the Kirkwood sand of Lawrence County.

A new pool was opened on the D. Hebert farm in Sec. 15, Allison Township, Lawrence County, late in July by the Ohio Oil Co. The first well produce initially 50 bbl., of oil from the Kirkwood sand and a second well, 40 bbl. These two wells are the only ones developed in the pool at present. Their combined daily production now is about 30 bbl.

Barren wells were drilled in 1913 near Murphysboro, Equality, Harrisburg, Duquoin, Hoffman, Hoyleton, Edwardsville, Millstadt,

Pinkstaff, Kingman, Lexington, Dundas, Anna, Olive Branch and Villa Grove. New drilling is going on or will soon start near Allerton, Vandalia Pesotum and Mahomet. The last two towns lie along the LaSalle anticline and drilling will go to the Trenton limestone.

On January 1, 1913, it was established that 21,238 wells had been drilled in Illinois. Of these, 3422, or 16.1 per cent., were barren. In 1913, 1,749 wells were drilled with 310 or 17.7 per cent. barren. The total up to January 1, 1914, is 22,987 wells drilled, with 3732, or 16.2 per cent. dry.

EIGHT-YEAR COMPARISON.

Year.	Wells Completed.	Wells Producing.	Initial Output, Bbl.	Dry Holes.	Average Yield per Well.	Total Production. Bbl.
1906	3,283	2,793	113,012	490	40.4	4,397,050
1907	4,988	4,260	139,163	728	32.6	24,281,973
1908	3,574	3,019	78,960	555	26.1	33,686,238
1909	3,151	2,593	89,756	558[1]	34.0	30,898,339
1910	2,139	1,671	93,256	468	55.8	33,143,362
1911	1,364	1,059	66,919	305	63.1	31,317,038
1912	1,256	986	65,686	257	66.6	28,601,308
1913	1,749	1,439	46,663	310	32.4	21,600,000

[1] Seventy gas wells included.

The abandonment of old wells is gradually decreasing the total of productive wells.

Kansas.—The marked drilling activity and extensive development which characterized operations in the Mid-Continent field as a result of the high price of crude oil in 1913 accounts for the increased output of Kansas. This state produced 2,375,029 bbl. of petroleum during the past year as compared with 1,592,796 bbl. over a corresponding period in 1912, an increase of 782,233 bbl. or approximately 49 per cent. The production of Kansas from 1909 to 1913 inclusive is as follows:

Year.	Production in Bbl. of 42 Gal.	Percentage, Increase.
1909*	1,263,764	.....
1910*	1,128,668	−10.7
1911*	1,278,819	11.7
1912*	1,592,796	24.5
1913	2,375,029	49.1

* Mineral Resources, 1912.

The Chautauqua County pool continued to furnish the best wells and the largest amount of crude daily. The Erie pool in Neosho County, a former prominent producer, declined rapidly. In Montgomery County, the greatest development was around Wayside, where oil was produced more than 10 years ago. It has been the policy to drill the new wells deeper and some of the old wells were deepened with good results also.

A few of the new wells started with a production of from 50 to 100 bbl. per day, but a majority of them were 5- to 30-bbl. producers.

Interest was renewed in the Rantoul and Paola areas. The Rantoul field lies principally in the southwest corner of Miami County and extending into Franklin County. Operators seem to have concluded that this is a favorable area and much development has resulted with the tapping of many new wells of 5 to 100 bbl. daily capacity. The Moran and Humboldt pools in Allen County as well as the Neosho County district gave many good wells.

When the prolific Newkirk pool in Kay County, Oklahoma was discovered developers and speculators rushed to the new field and covered the entire country with leases, even northward 20 or 30 miles into Kansas. Indications point to active drilling and "wildcatting" in this territory during 1914. A line of mild dynamic disturbances extends from the Newkirk area northeast by the way of Dexter, Augusta, and Elmdale, entirely across the state of Kansas. The few gas wells obtained at Winfield, Dexter, Augusta and Elmdale have been found along little anticlines existing in this disturbed area. Companies have now been formed and oil leases have been taken as far north as the Kansas river in the vicinity of Wamego.[1]

Kentucky-Tennessee.—The yield from this field for 1913 is estimated at 524,568 bbl., a slight increase over the corresponding period in 1912 when the production was 484,368 bbl. The wells in Wayne County, which includes the Denny-Griffin, Cooper, Steubenville and Parmleysville districts, were responsible for a large part of the output as in previous years. The Cannel City pool in Morgan County made an excellent showing, however. The following table shows the percentage yield of the total from each district in 1913:

District.	Percentage Yield.
Busseyville	2.5
Denny-Griffin	33.0
Cooper	13.0
Steubenville	9.0
Parmleysville	8.0
Cannel City	18.0
Campton	5.0
Stillwater	1.0
Ragland	8.0
Beaver Creek	2.5
Total	100.0

The well record for Kentucky in 1913 indicates the most active period of prospecting and development during the last 6 years. There were 211 completions with 74 dry holes and 3 gas wells The well record from 1908 to 1913 inclusive is as follows:

[1] Erasmus Haworth, *Eng. Min. Jour.*, Jan. 17, 1914.

Year.	Completions.	Initial Production, Bbl.	Dry Holes.	Gas Wells.
1908*	200	2,442	46	19
1909*	171	2,186	53	26
1910*	121	829	50(a)	.....
1911*	136	1,822	33(a)	.....
1912*	178	1,943	61(a)	.....
1913	211	2,310	74	3

(a) Gas wells not included.
* From Mineral Resources, 1912.

Lima-Indiana.—The alarming decline which has marked the progress of this field during the past few years was partially halted in 1913 as a result of the discovery of a new pool in Sullivan County, Indiana. The total production for the Lima, Ohio-Indiana field in 1913 is placed at 4,773,138 bbl. Of this, 3,817,043 is to be credited to Ohio, and 956,095 to Indiana, as compared with 970,000 bbl. in Indiana in 1912. The well record of the Lima-Indiana field for the past year as compiled from the reports of the *Oil City Derrick* is as follows:

Field.	Completed Wells.	Initial Daily Production.	Dry Holes.	Gas.
Lima-Indiana	1,280	18,639 bbl.	169	17

The discovery of the Shelburn-Sullivan pool was the feature which characterized development work during the past year and this field is now the most active in the central west. The shallow depth of the pool has stimulated very active drilling and "wildcatting," and as a result the limits of the pool have been extended considerably. Heavy bonus prices have been paid for leases which have failed to make a showing as yet. The field is very spotted, dry holes being encountered in close proximity to 200- to 500-bbl. wells. A production of 2700 bbl. per day from 110 producers was obtained from this pool near the close of the year. Indications point to extensive drilling operations in 1914. One of the main problems with which operators have to contend with in the Indiana fields is the lack of cheap fuel for pumping purposes.

Ohio (By J. A. Bownocker).—Ohio showed a decreased production in 1913, the output for the entire state being 8,780,468 bbl. of which 4,964,425 bbl. came from the southeastern and central fields and the remainder from the Lima pool in the northwestern part of the state.

The production of Ohio by districts for the last 11 years is as follows:[1]

[1] Statistics 1903–1912 from Mineral Resources of U. S., 1912.

Year.	Lima Field.	Southeastern Ohio.	Mecca-Belden.	Total.
1903	14,893,853	5,585,858	575	20,480,286
1904	13,350,060	5,526,146	425	18,876,631
1905	11,329,924	5,016,646	90	16,346,660
1906	9,881,184	4,906,399	180	14,787,763
1907	7,993,057	4,214,298	93	12,207,448
1908	6,748,676	4,109,935	186	10,858,797
1909	5,915,357	4,717,069	367	10,632,793
1910	5,094,136	4,822,193	41	9,916,370
1911	4,535,875	4,281,173	64	8,817,112
1912	(a)3,955,897	5,013,051	59	8,969,007
1913	(a)3,817,043	4,964,425	.....	8,780,468

(a) Includes Michigan. All production in barrels of 42 U. S. gal.

Notwithstanding the high price of petroleum, the year 1913 was one of the least notable of the many years that Ohio has been producing this fuel. In the old Trenton limestone field (Lima) of the northwestern part of the state, wells are occasionally drilled but to one new producer a half dozen old wells are abandoned. The outline of this field has not changed in 10 years and there is no reason whatever to expect a change in the future. Each year the production should decrease and the output in 1913 was a small part of what it was a few years ago.

In the "Clinton" sand field of Central Ohio more work has been done and with better results. Especially has this been true in the vicinity of Gore and Union Furnace, Hooking County, where some good wells have been obtained. Efforts to find oil in this sand farther south in Vinton and Jackson Counties have been failures. Farther north, that is in Wayne and Medina Counties, some drilling has been done for oil but without results in harmony with the money and labor expended. Many strings of tools are still at work in southeastern Ohio and producing wells are obtained, but practically all of them are in or along the border of old fields. This territory also is past its zenith and drilling has been so extensive that discovery of large pools can hardly be expected. The well record for southeastern and central Ohio as compiled from the reports of the *Oil City Derrick* is as follows:

Completed Wells.	Initial Daily Production.	Dry Holes.	Gas Wells.	Field.
1,705	13,263 bbl.	476	52	S. E. Ohio.
472	2,159 bbl.	118	300	Central Ohio.

Within the past year or two a patented arrangement has been introduced into the southeastern field to rejuvenate the flow of oil wells. The device is very simple and the process consists of forcing air down into the oil rock and thus restoring the pressure conditions that existed when the territory was first drilled. The result has been to increase the production of some wells more than 100 per cent. Wells that have been abandoned for years have been cleaned out and made productive. Whether

the principle will be successful when applied to deep wells which are farther apart remains to be seen.

Oklahoma.[1]—The year 1913 has been by far the most active that the Oklahoma field has seen. This has been due in a large measure to the price paid for oil which has been much higher than for any previous year and which has stimulated extensive exploration and development. Beginning with $0.83 per barrel on January 1, the price advanced to $0.88 by the end of January, to $0.93 on July 7, to $0.98 on July 21 and to $1.03 in August at which price it remained for the balance of the year.

The total production for Oklahoma in 1913 was 63,579,384 bbl.,[2] an increase over 1912 of 12,152,313 bbl. or 23.6 per cent. The production and value of the petroleum of Oklahoma since 1908 is shown in the following table:

Year.	Production, Bbl.	Value.
1908	45,798,765	$13,694,843
1909	47,859,218	$17,428,990
1910	52,028,718	$19,992,660
1911	56,069,637	$26,451,767
1912	51,427,071	$34,672,604
1913	63,579,384	$59,581,948

This remarkable increase of $26,512,522 or 72 per cent. over 1912 gives Oklahoma first rank among the states in the value of the oil production. Although stocks on hand have increased slightly over the previous year (51,619,663 bbl., as compared with 48,385,698 bbl.), production and consumption have been practically equivalent.

The well record for Oklahoma for 1913 by months is shown by the following table, condensed from the reports of the *Oil City Derrick* and the *Petroleum Gazette:*

	Holes Completed.	New Production, Bbl.	Dry Holes.
January	601	20,760	78
February	518	19,505	55
March	527	19,730	88
April	667	26,290	54
May	783	27,199	74
June	883	32,188	135
July	884	25,072	179
August	864	27,397	130
September	776	27,267	97
October	830	30,956	125
November	845	29,222	128
December	934	43,173	163
1913 Total	9,112	330,259	1,306

[1] From Press Bulletin, Oklahoma Geological Survey, C. W. Shannon, Director.
[2] *Fuel Oil Journal*, Houston, Texas.

This shows practically 14 per cent. of dry holes, whereas the well record for 1904 to 1912 inclusive shows 11.2 per cent. of dry holes. The increase in percentage of dry holes is to be expected in view of the great amount of promiscuous "wildcatting" which is done at present. Attempts to carry the production south into Okfuskee and Seminole Counties were not successful. The wells drilled in these counties were too few to condemn the territory entirely, but the present prospects do not look favorable.

The Healdton pool west of the Wheeler field, near Ardmore, was of especial interest and although no phenomenal gushers were discovered, a score of successful wells were brought in. One 20 acre lease was sold for $1000 an acre, undeveloped, half in cash and half from the first oil. One 53 acre tract in fee sold for $1000 an acre. The Gypsy Oil Co. has paid $50,000 for a half interest in the acreage of The Humble Oil Co. which has three wells. The structure at Healdton has been condemned in the past by many geologists. Some dry holes in apparently favorable territory make it appear as if the field were spotted.

An interesting and very rich pool has been uncovered in the vicinity of Inola, Oklahoma, southeast of Claremore. Here, at a depth ranging from 400 to 650 ft., a number of good wells have been obtained, some of which produce as much as 300 bbl. a day. Special interest attaches to this field on account of its being so far to the southeast and substantially outside of what has hitherto been considered the productive area.

Probably the most remarkable development for all Oklahoma is in Washington and Nowata Counties. The old fields in Washington County around Bartlesville, Dewey, Copan, and Wann are a surprise to everybody. Wells have been obtained recently producing as high as 600 bbl. a day and it seems difficult to drill a random hole anywhere in this vicinity without striking oil or gas.

The Boston pool in the Osage nation territory proved to be one of the richest and best developments of the year. Other new pools of promise were the Collinsville, the Wicey, southeast of Tulsa, a pool at Newkirk, north of and on the same structure as the Ponca City wells, the Keystone development, and a well at Allen, near Ada in Pontotoc County in the same geologic region as the main fields, but far to the south of any previous development. The Cushing pool was again very productive, giving many good wells.

The yearly production of Oklahoma, divided into fields, is as follows:[1]

[1] *Fuel Oil Jour.*, Mar., 1914.

Field.	Production, Bbl.	Field.	Production, Bbl.
Osage Nation	8,561,933	Skiatook, etc.[1]	7,340,621
Cleveland	3,970,878	Jenks and Perryman	857,996
Cushing	8,386,749	Bixby	495,406
Kelly	8,025	Bald Hill	1,847,791
Keystone	26,714	Morris	2,694,124
Lost City	246,854	Schulter	1,073,644
Glenn Pool	6,246,387	North Lenepah	45,176
North Extension	2,671,352	Delaware	1,135,758
Mounds	137,157	Nowata & Coodys Bluff	3,145,950
Hamilton	297,575	Collinsville	265,992
Tiger Flats	236,696	Haskell	26,165
Henryetta West	73,232	Wainwright-Boynton	4,442
Copan	1,577,697	Chelsea & Alluwe	2,557,195
Bartlesville-Dewey	8,410,024	Muskogee	421,751
shooter	919,755	Ponca City	722,358

[1] Skiatook, Bird Creek, Flat Rock, and Turley.

Grand total for year	64,405,397	bbl.
Monthly average	5,367,116	bbl.
Daily average	179,467	bbl.
Daily average per day per well	6.61	bbl.

Pennsylvania and New York (By Richard R. Hice).—Notwithstanding the unparalleled activity in drilling and the greater attention given to the care of the older wells, the Pennsylvania production for 1913 reached only 7,963,282 bbl. The value of the output, however, will be largely in excess of that of the previous year, $19,905,452.

The following table gives the production of Pennsylvania for the last 10 years.

PRODUCTION AND VALUE OF PETROLEUM IN PENNSYLVANIA, 1903-12.

Year.	Quantity, Bbl.	Value.
1903	11,355,156	$18,170,881
1904	11,125,762	18,222,242
1905	10,437,195	14,653,278
1906	10,256,893	16,596,943
1907	9,999,306	17,579,706
1908	9,424,325	16,881,194
1909	9,299,403	15,424,554
1910	8,795,662	11,908,914
1911	8,248,158	10,894,074
1912	7,837,948	12,886,752
1913	7,963,282	19,805,452

Four thousand two hundred twenty-nine wells were completed in the New York and Pennsylvania fields in 1913, as against 2973 wells in the same territory in 1912. This increase of more than 100 per cent. in the number of completions was the inevitable result of the higher prices of crude petroleum, beginning with $2 per barrel the first of the year, reaching $2.50 before the first month was closed, and remaining at that price throughout the year. With the premium over the regular price paid by some purchasers, the average price for 1913 was probably slightly over $2.50 per barrel.

The figures compiled by the *Oil City Derrick* give the following results of field work in the several districts of the state:

RESULTS OF FIELD OPERATIONS IN NEW YORK AND PENNSYLVANIA, 1913.

District	Completions
Allegheny	510
Bradford	757
Middle	427
Venango-Clarion	1,579
Butler-Armstrong	498
Southwest Pennsylvania	458
Total	4,229

Of these 308 were gas wells and 517 were dry holes, leaving 3404 producing wells, with a total initial production of 8,962 bbl., an average of 2.6 bbl. per day.

In the fields producing Pennsylvania grade of oil, including New York, Pennsylvania, West Virginia and southeastern Ohio, the total production in 1913, according to the figures collected by the Oil City Derrick, was but 93,176 bbl. more than the output in 1912. In West Virginia there were 2972 wells completed and in Ohio 1705 wells, a total, including the 4229 in New York and Pennsylvania, of 8006 wells. The total initial production from all four states was, according to the same authority, 56,512 bbl., an average of more than three times the average for Pennsylvania. It is to be noted that the entire increased production was less than the initial production of the new wells for two days, indicating a very material falling off in the output of the older wells.

Texas and Louisiana (By W. E. Wrather).—The entire production of crude oil in Texas during 1913 was 15,009,478 bbl. valued at approximately $1 per barrel as compared with the production of the preceding year of 11,735,057 bbl., valued at 75.4 cents per barrel, an increase of 27.9 per cent. and $5,822,880 respectively. Louisiana also made a gain of 34.9 per cent. in production and $5,232,104 in value, the final returns showing a total production of 12,255,931 bbl., valued at 96 cents per barrel as compared with 9,263,439 bbl., valued at 75.8 cents per barrel in 1912. Over 9,000,000 bbl. of the Texas production was light gravity oil from the Clay and Wichita County fields. Over 10,000,000 bbl. of the years output in Louisiana came from the Caddo field and the newly developed Mansfield pool in DeSoto Parish, both in the northwestern part of the state. The remainder of approximately 2,000,000 bbl. represents the yield of the heavy oil from the Louisiana coastal pools. The heavy oil pools of Texas, with one or two minor exceptions, showed a decline from the production of 1912.

Four new pools were discovered during the year: Mansfield, Edgerly, Orange, and Moran; the first two in Louisiana and the latter two in Texas. At least the first three named bid fair to become consistent pro-

ducers. Edgerly and Orange are in the coastal heavy-oil belt; Mansfield belongs to the Cretaceous Light-oil district of northwestern Louisiana, and the Moran sand is in the Pennsylvania section of northwest Texas.[1]

The Mansfield pool appears thus far to be the most important discovery of the four. The first well, completed early in May, has settled down from 1500 bbl. to a consistent producer, making about 500 bbl. per day. The field was removed from the doubtful class when two new wells were finished in November, one making 500 bbl. and the other 650 bbl. They are located, respecitvely, 1/4 mile southwest and 3/8 mile northeast of the discovery well. At the close of the year another good well was brought in by the Pasadena Petroleum Co. It started flowing at the rate of 3600 bbl. per day.

Moran also produces light gravity oil though its future will remain in the balance until more drilling has been done. The only oil well thus far developed is now making about 60 bbl. of 35 (Be') gravity oil from a 2000 ft. sand. Deeper holes have been drilled within a short distance of the producing well without finding any oil and the feeling is none too optimistic. The sand is in the Cisco beds, in the top of which most of the important workable coal of Texas is found. The field generally is classed with Electra although located about 110 miles south of that point.

Orange and Edgerly, only 25 miles apart, one in southeast Texas, the other across the Sabine river (to the east) in Louisiana, have not been suffiicently drilled to obtain a fair estimate of their possibilities. At Orange only one well is producing, from an unusually deep sand at 3150 ft., but at the end of its fourth month it is flowing about 180 bbl., a decline of only 70 bbl. since its completion last August. Edgerly is the scene of considerable activity. Although the production of the pool is not more than 500 bbl. Some months ago oil was found in small quantities between 1500 and 1600 ft., and in August a 2350-ft. well made a daily yield of 600 bbl. of heavy black oil,though it settled down within a few weeks to a small well. In October a deeper sand, at 2750 ft., was discovered and a well was brought in flowing around 1000 bbl. of 18° (Bé.) gravity black oil. This well now makes some water, with from 300 to 400 bbl. of oil. In December, a sand was developed at 3000 ft., and in 44 hr. this well made 5900 bbl., the sand choking off the flow. The depth of the well and volume of the flow indicate a rich oil deposit. It appears reasonably certain that both Edgerly and Orange will become profitable pools.

The discovery of deep oil sand at the above places has given rise to the belief that the deep sands of the Gulf Coast will eventually produce much more oil than has heretofore been thought probable. This view has been held for several years by geologists familiar with the section, among them

[1] *Eng. Min. Jour.*, Jan. 17, 1914.

L. Hager and W. Kennedy, and this idea led to the discovery of oil at Orange under Mr. Kennedy's direction. Deeper drilling along the coast will undoubtedly be stimulated in the future because of this development.

On the outskirts of Humble and Batson, deep oil was found during the year. About a mile east of the Humble pool proper, several unusually good wells have been completed at 2750 ft. One temporarily made at the rate of 10,000 bbl. per day until the casing collapsed. It was drilled again and is now making 4000 bbl. daily.

At Batson, the deep oil seems to occur under the same conditions as at Humble, though scarcely so deep. The gravity ranges about 34° Bé., but the area on the west side of the pool, where deep oil has been found, seems limited and the development is relatively unimportant.

In other coastal fields, little of interest has happened. Vinton, within sight of the new Edgerly pool, is on a steady decline. Pine Prairie has long ago ceased to be a possibility. Goose creek occasionally furnishes a fair well, but the territory is very erratic. It is worthy of mention that another typical salt dome was found during the year in Brazoria County, 8 miles south of Angleton, though it showed no oil and only small quantities of gas.

In north Texas the production continues to increase. Electra's output is estimated at 28,500 bbl. daily. The deep sand (1560 to 1900) furnishes the best wells and from them comes the bulk of the production.

An occasional 500 bbl. well is found on the southwest side of Petrolia, though this locality has been largely a gas producer throughout the year. The present oil production is not more than 1500 bbl. daily. Burkburnett furnishes about 1200 bbl. per day, but the results of late are not encouraging.

The history of the Caddo pool was practically a repetition of that of the preceding year. Several phenomenal wells have been finished in different portions of the field, though seldom, if ever, has it been possible to bring in a second well of similar size in the immediate vicinity. The bed of Ferry lake has proved to be some of the best territory in the field. The best results of the year have been obtained in the south end of the pool around Mooringsport. The daily light oil production has ranged between 17,500 bbl. (for January, the lowest of the year) to 32,500 bbl., the fluctuation being due principally to the completion of large wells, which soon declined to a normal figure. The heavy oil production has averaged about 3000 bbl. daily.

The market for Texas and Louisiana "crude" during 1913 was stronger perhaps than it has ever been, all grades bringing higher prices than during the preceding year. Electra, Petrolia, and Corsicana, all light gravity, refining oil, advanced from 88 cents to $1.05 per barrel,

while Caddo "light" advanced from 91 cents to the same figure. The limited production of heavy oil at both Caddo and Corsicana resulted in an advance of from 10 to 15 cents per barrel, bringing respectively 75 and 80 cents at the close of the year.

In the Coastal fields the production, although a heavy gravity oil, is being extensively refined, principally for lubricants, and competition among the refiners for the decreasing supply crowded the price at the beginning of 1913 to as high as $1.07 7/8 per barrel, this price having been paid on 12 months contracts at Sour Lake, Batson, and Saratoga. With the menace of an increasing importation of Mexican fuel oil, producers were anxious to close contracts at the high prices offered for as long a period as possible. The result was that all free oil, that is, oil not controlled by the pipe lines, was tied up under contracts, the majority of which did not expire until after Jan. 1, 1914. With the prospects of both Edgerly and Orange developing into important pools, the present tendency is toward lower prices.

Complete statistics recently published by the *Fuel Oil Journal* show that the imports of Mexican crude oil into the United States during 1913 amounted to 16,588,067 bbl. Of this amount 10,757,980 bbl. were delivered at Texas and Louisiana ports for the fuel-oil trade, the declared value per barrel being 60.4 cents. The largest individual consumers of Mexican fuel oil in the two states during the year were the Southern Pacific Railway which used 1,784,143 bbl. on its rail and steamship lines, and the Union Sulphur Co. Sulphur, Louisiana, which used 1,128,169 bbl. for steaming purposes in connection with the Frasch process of extracting sulphur.

West Virignia (By I. C. White).—The production of petroleum in the year 1913 was 11,567,299 bbl., valued at $28,828,814, compared with 12,128,962 bbl., with a value of $19,927,721, in 1912, the average price per barrel having been $1.643 for that year, while for 1913 the average price was much higher, since the price of the Pennsylvania grade of petroleum rose to $2.50 per barrel in February, 1913, and remained at that figure.

The year was specially marked by the rapid decline in production of the Blue Creek oil pool of Kanawha County, the finding of paying wells in Clay County, and some wells of the gusher class in the Fourth Sand horizon of Sardis District, Harrison County, in the old region of Wallace on the waters of Ten Mile creek where some good producers were developed in the Gordon Sand as far back as 1899.

What appears to be a new Big Injun pool was also developed in a previously untested portion of Wirt County during the last days of the year by the Walnut Creek Oil Co. This pool was located for that

company in "Wild Cat" territory by Ray V. Hennen, Assistant Geologist of the W. Va. Geological Survey, entirely on stratigraphic data, and is thus another triumph of the scientific method applied to the oil business. Some large Berea Sand wells were also discovered near Spencer, Roane County, during the year 1913, through suggestions given the oil fraternity by Mr. Hennen in his report on Wirt, Roane and Calhoun Counties.

In addition to the new developments cited, several other good spurs from old fields were discovered during the year, notably those on the Tennant and McFeeter farms in Battelle district, Monongalia County, while several extensions and spurs from old pools were also found in Marion, Wetzel, Ritchie, Pleasants, and Tyler Counties. The Wier or Squaw Sand of the Falling Rock region in Elk District, Kanawha County, was also a new development of the year 1913, although the region was developed for gas by Mr. Wier as long ago as 1910, while some oil accompanied the first gas wells, it was not found in commercial quantity until early in 1913.

Wyoming.[1]—Despite the handicap of insufficient refinery capacity, necessitating a curtailment in the possible output, Wyoming made the substantial gain of 53 per cent. in the production of petroleum during 1913. The total for the year was 2,406,522 bbl. of 42 gal. as compared to 1,572,306 bbl. in 1912. The Salt Creek field was responsible for 95 per cent. of the production which was divided as follows:

Salt Creek field	2,274,843 bbl.
Crowley or Byron field	43,659 bbl.
Lander-Dallas field (asphalt)	29,693 bbl.
Spring Valley field	5,216 bbl.
Douglas field	500 bbl.
Moorcroft field	100 bbl.

The prices varied from $0.40 per barrel for the heavy asphalt oil to $1.50 per barrel for the paraffin base oil high in gasoline content.

As the Salt Creek refinery capacity has been unable to handle the possible production from completed wells, drilling in the proven territory was greatly curtailed. Several wells in the outlying shale area, however, drilled into oil during the year. "Wildcating" in the Bothwell syncline west of the Salt Creek field was unproductive of results although a score of holes were drilled.

One to two hundred barrels per day were reported from the Crowley or Byron field. The production is being marketed by the Mutual Oil Co. of Salt Lake which has enlarged the refinery at Crowley to a daily capacity of 500 bbl.[2] It is reported that the entire field has been purchased by the Ohio Oil Co. which will again enlarge the refinery to handle the entire production now possible, about 1200 bbl. per day.

[1] From statistics and data supplied by L. W. Trumbull, State Geologist.
[2] C. E. Jamison, *Salt Lake Min. Rev.*, January 15, 1914.

Near Cody, Park County, two fields have been brought to the producing stage. In the Oregon Basin field, the Mineral Oil Co., a French concern, have carried on an extensive campaign of development throughout the year, bringing in a number of good wells. In the Cody field, 2 miles east of the town of Cody, the Mountain States Oil Co. has three producing wells. The oil from the fields is not marketed at present as no refinery is at hand.

A production of 125 bbl. per day was made by the Wyopo Oil Co. in the Dallas field near Lander. A small irregular production was also reported from the Wind River reservation in the Lander district.

South of Riverton, Fremont County, in the Conant Creek field, the Mountain States Oil Co. struck a small well at 1325 ft. A number of shallow wells were drilled near Douglass, Converse County, during the latter part of the summer, 10 to 20 bbl. wells being obtained at 300 ft. A 2-in. pipe line will be laid to the railroad and a small refinery will be erected.

The Secretary of the Interior granted a permit for further drilling in the withdrawn area of the Greybull-Basin field in order to increase the rapidly failing gas supply of the towns of Greybull and Basin. Five new wells were drilled, oil being obtained in three and gas in two, thus proving a new dome in this locality. Drilling in the Moorcroft field was effectively stopped by the recent withdrawal order of the government.

The Federal Court decided against the government in its suit to compel surrender of sections owned by the Midwest Oil Co. on the ground that the withdrawal of sections was made before the president was so authorized by Congress and therefore not valid. Before a second authorized withdrawal had been made, the Midwest Co. had entered the field and commenced to produce oil.

The outlook for 1914 is especially promising. The Midwest Co. has enlarged its refinery, doubling the capacity while the Standard Oil Co. of Indiana and the Franco Petroleum Co. are erecting refineries. With the completion of the new plants, Casper refinery capacity will amount to 27,100 bbl. per day.

Petroleum in Foreign Countries

The features of chief interest in connection with the foreign petroleum industry in 1913 was the active prospecting for new oil deposits, according to David T. Day. This prospecting extended to very remote regions including South Africa, southern Chile, Patagonia, many islands of the Pacific, China, Japan, and the East Indies. The prospecting of most interest to the United States was that in the West Indies, Central America,

and South America, on account of the approaching completion of the Panama Canal.

PETROLEUM OUTPUT OF THE WORLD. (*a*)
(In metric tons.)

	1907	1908	1909	1910	1911	1912	1913
United States	22,287,985	24,401,728	24,433,528	28,331,000	29,001,100	29,906,416	33,702,414
Russia	8,435,708	7,654,600	8,037,300	(*f*) 8,952,793	9,167,600	9,249,600	9,474,876
Dutch East Indies	2,200,000	2,348,000	1,497,275	1,700,000	1,670,688	1,520,000	1,528,220
Galicia	1,176,000	1,754,002	2,150,000	1,700,000	1,454,660	1,180,568	1,090,000
Rumania	1,129,097	1,147,727	1,263,946	(*f*) 1,352,300	1,544,847	1,806,942	1,885,225
India	587,000	568,000	905,336	(*c*) 863,615	(*c*) 907,684	(*c*) 1,001,316	(*e*) 1,100,000
Mexico	294,000	587,000	405,000	(*f*) 542,400	(*d*) 968,277	(*d*) 2,646,000	3,612,451
Other countries (*e*)	296,000	293,000	505,000	(*f*) 786,480	750,000	800,000	(*e*) 900,000
Total	36,405,790	38,754,057	39,197,385	44,236,973	44,465,856	48,110,742	53,293,186

(*a*) In the above table the statistics for the United States are computed from the production reported in barrels as given in the first table of this article. As a gallon of the crude petroleum found in the United States varies in weight from 6.41 to 7.83 lb., the oil in a barrel varies from 269.22 to 328.86 lb. The arithmetical mean of these figures is 299.04 lb., which figure has been used as a factor in converting the output stated in barrels into metric tons. This is not strictly correct, because in the period from 1900 to 1910 the proportion of petroleum production of various gravities has altered materially, especially because of the largely increased production in California, Texas and Louisiana. However, the method adopted is as near an approximation as can be made at this time. (*b*) Included in other countries. (*c*) On the assumption that 1 imp. gal. weighs 4.02 kg., equivalent to a density of 0.885. (*d*) On the assumption that 1 U. S. gal. weighs 3.5 kg., corresponding to a density of 21°B., or 0.925. (*e*) Estimated. (*f*) *Oil Investors' Journal.*

Argentine Republic.—L'Intermédiaire de Buenos Ayres states that the mixed exploitation of the Argentina State oil lands at Commodore Rivadavia by the State and a syndicate under Rothschild auspices is the subject of a Bill recently introduced by a private member in the Argentinian Parliament. The syndicate offers, as a consideration for a temporary concession to exploit the land under the control of the Government, the amount of P. 30,000,000, payable at once and one-half of the net profits. The President of the Argentinian Board of Agriculture, believing that the whole of the profits ought to be earned by the state, is stated to be opposed to the proposal. Meanwhile, it is authoritatively stated that the government-appointed engineering party engaged in the exploration of the Commodore Rivadavia oil lands has discovered new oil-carrying strata at a depth of 525 meters near the Bay of San Jorge, on the Atlantic. The exploration works are being continued.

Reports from the Argentine show rapid development. Almost every day new wells are opened up, and although the crude oil recovered is not first class, the output increases. At Comodoro Rivadavia there are twelve wells with an average depth of 515 meters. Well No. 4 yields 105 cubic meters of crude oil per hour, which sells at 35 pesos per 1000 liters, the railway consuming on an average 3000 tons monthly. Eight private companies are engaged in the petroleum-producing industry. A quay, exclusively intended for loading petroleum, is now in course of construction. The Argentine Government has reserved for the state 5000

hectares of oil lands, 350 of which are now in course of exploitation. A refinery is being installed, the main work of which will be to eliminate from the crude oil the light essential oils in order to make it suitable as fuel for warships. Crude oil is also being extensively used for generating electric power.

Austria-Hungary.—The production of petroleum in Galicia for 1913 was 1,090,000 metric tons as compared with 1,187,000 metric tons for 1912, a decrease of 97,000 tons or 8.2 per cent. Although the output has decreased steadily since the record production in 1909 of 2,076,740 metric tons, the large number of deep bores which are constantly being sunk in the central and eastern portions of the petroleum area are expected to check this decline. During 1913, the Tustanovice production receded steadily; Boryslav, however, has been recovering lost ground of late due to the opening of several new wells.

Canada.[1]—The production of crude petroleum in Canada was still confined during 1913 to the old established fields in Ontario with a few barrels pumped from gas wells in New Brunswick. The annual output has been steadily declining during the past 6 years and shows a further falling off in quantity produced in 1913 although owing to the higher price obtained for oil a larger total value is shown than for 1912.

A bounty of 1 1/2 cents per imperial gallon is paid upon the production of crude petroleum, the Bounty Act being administered and payments made by the Department of Trade and Commerce. According to the records of this Department the total output of petroleum in 1913 was 228,080 bbl., on which a bounty of $119,741.97 was paid. The total value of the production at the average price for the year $1.782 per barrel was $406,439. The production in 1912 was 243,336 bbl., valued at $345,050 or an average value of $1.418 per barrel.

The average price per barrel at Petrolia during 1913 increased from a minimum on January 1 of $1.65 to $1.75 on April 16, $1.84 on November 6, and $1.89 on December 22.

The production in Ontario by districts as furnished by the Supervisor of petroleum bounties was in 1913 as follows, in barrels: Lambton 155,747; Tilbury 26,824; Bothwell 34,349; Dutton 4610; Onondaga 4172 and Belle River 464, or a total of 226,166 bbl. In 1912 the production by districts was: Lambton 150,272; Tilbury 44,727; Bothwell 34,486; Dutton 4335 and Onondaga 7115 or a total of 240,935 bbl.

The production in New Brunswick in 1913 was 2111 bbl. as against 2679 bbl. in 1912 and 2461 bbl. in 1911.

Calgary, Alberta, and contiguous territory experienced a tremendous oil boom during the past year as a result of a small well brought in by the

[1] Preliminary Report, Mineral Production of Canada, Canadian Bureau of Mines, 1913.

Calgary Petroleum Products Co. Oil and tar exuded from the ground, in many places, the presence of Cretaceous sandstones overlain by impervious strata, and favorable geological structure indicate great commercial possibilities. Gas has been found in large quantities but no strong producing wells have been struck to date. English interests, represented by Cunningham Craig, Standard Oil, Union, and Doheney interests are acquiring large holdings. The High Commissioner's office states that Rockefeller interests have joined with Canadians in a five-million-dollar company to prospect for oil in Alberta.

India.—According to the annual report of the Director of the Geological Survey of India for 1912, the decline which occurred in the production of petroleum in Burma in 1911 was followed by a large expansion in 1912. The deeper sands tapped at Yenangyuang led to a considerable advance in the output of that district, which reached a total of 180,000,000 gal. The aggregate production of India was 16,000,000 gal. in excess of the highest figures previously recorded, amounting to over 249,000,000 gal. A reduction occurred in the imports of foreign kerosene, from 75,000,000 to 62,500,000 gal.

Mexico (By L. G. Huntley).—Production and Stocks. As shown by the following table, Mexico's oil production has increased almost 50 per cent. over the preceding year of 1912 in spite of the fact that 1913 saw the first active field operations of the Mexican Constitutionalists in the oil territory.

PRODUCTION OF PETROLEUM IN MEXICO, 1907 TO 1913 INCLUSIVE

Year	Production in Bbl.
1907	1,000,000
1908	3,481,410
1909	2,488,742
1910	3,332,807
1911	14,051,643
1912	16,588,215
1913	24,574,500

Stocks on hand December 31, 1913, amounted to 11,656,000 bbl.

Mexico now has a total of approximately 350 wells drilled, drilling or for which locations have been made. At the close of 1913, there were 97 wells drilling in the field. It would be difficult to state accurately the number of completions during the year as many wells were shut down for various reasons, among which title disputes and transportation difficulties figure largely. Approximately 130 completions are credited to the 12 months preceding April, 1914.

Of the 350 wells drilling or completed, 90 or more belong to the Pearson interests, and about 50 to the Huasteca Petroleum Co. and the Mexican Petroleum Co. All the large wells in the various districts have been shut in or have had the gate-valve only cracked, except

the No. 7 Casiano of the Huasteca Petroleum Co., which cannot be closed in without ruining the well.

The daily average production of the Mexican fields for 1913 was 70,000 bbl. of crude from approximately 50 producing wells. This has been increased since the first of the year to better than 75,000 bbl. due to the bringing in of several large gushers in the Panuco area. If all the wells were turned loose, the daily production would be more than doubled in a short time. An estimated total capacity of 180,000 bbl. per day from all wells in the Mexican field may be divided as follows:

Production.	Field.
70,000	Panuco
4,000	Topila
6,000	Ebano & Chijol
30,000	Juan Casiano
70,000	South Field shipping from Tuxpam, including Petrero del Llaon.

Companies.—There are now 187 companies engaged in the oil business, of which fifty are actually operating. A large proportion of the balance were organized during the first part of 1914. Twenty-five companies are actually producing.

The Pearson Co. (Mexican Eagle Petroleum Co.) produced about half of the 24,574,500 bbl. for 1913, and the Hausteca Petroleum Co. and the East Coast Co. produced the greater part of the balance. Since that time the Dutch Shell interest has come into the market with their No. 5 well at Panuco, which proved an enormous gusher, variously estimated at 33,000 to 100,000 bbl. per day.

Equipment.—There are now 425 miles of 8-in. pipe line in operation with 50 miles or more under construction. There are also 86 miles of narrow gage railroad used in connection with the oil fields with 35 miles under construction and 54 miles projected. Nearly all of the large producing companies have a fleet of tank steamers which is constantly being increased.

Market.—The greater part of Mexico's oil production is shipped to United States ports, the principal ones being Port Aransas, Galveston and Sabine Pass in Texas, New Orleans, Tampa, Jacksonville, Baltimore, Chester (Philadelphia), New York (Newark and Perth Amboy), and Providence.

The total imports of Mexican crude into the United States for 1913 equal 16,588,067 bbl. The heaviest importers are the Magnolia Petroleum Co. of Texas, the Southern Pacific Railroad, the Standard Oil Co. of New Jersey, the Standard Oil Co. of Louisiana, the Gulf Refining Co., the Texas Co., and the Interocean Oil Co. Galveston still imports the largest amount of any American port, with Sabine second.

Prices.—The official average price for Mexican crude for the year was 40

cents gold per barrel at Tampico, which makes the year's output represent a value of $9,829,800 (American currency). One or two producing companies consign oil to themselves in the United States at figures less than this average price. The charges on oil from the Panuco field to United States ports are as follows, expressed in American currency:

	Per Barrel.
Barging from Panuco to tanks at Tampico	$0.08
Pumping charge, loading ship from tanks	$0.03
Government and State taxes, $1.50 per ton, Mexican currency	$0.16
Freight Tampico to U. S. ports	
2 days to Port Aransas	
3 days to Galveston or Sabine Pass	
10 days to New York at $0.10 per ton per day	$0.05 to $0.25
Total charges	$0.32 to $0.52

The declared value at United States ports for Mexican oil averaged $0.526 from Tampico and $0.552 from Tuxpam. This would make the total product for 1913 equal to $13,245,655 in value; however, at the point of delivery, the actual value of oil imported for the fuel market is nearer $1 per barrel.

The oil produced in Mexico is divided roughly into two classes: one of heavy gravity, varying from 10 to 14° Bé. (0.993 to 0.973 sp. gr.), and one of light gravity, varying from 18 to 22° Bé. (0.947 to 0.922 sp. gr.). The first of these grades is secured from the Ebano, Panuco, and Topila fields west of Tampico; the second is produced from the central and southern fields, notably at Juan Casiano and Potrero del Llano.

A small quantity of very light crude oil, 30 to 40° Bé. (0.840 sp. gr.), has been discovered in the extreme western part of the latter areas where no promising developments are assured.

Panuco Field.—The beginning of 1914 was featured by remarkable developments in the Panuco field, the Dutch Shell Co. bringing in their famous Corona No. 5 gusher with a daily estimated capacity of 33,000 to 100,000 bbl. It is only a question of pipe line completion and transportation facilities to make Panuco one of the greatest producing areas in Mexico. Since the opening of several enormous wells in this field, all the steel storage has been filled, and greatly increased earthen storage has been necessary to take care of the production. The companies at Panuco are moving only 28,000 bbl. a day whereas the present rate of production averages 50,000 bbl. per day, the balance being stored in earthen sumps.

Barging equipment at Panuco is capable of loading only 105,500 bbl., but additional equipment has been ordered which will provide for a total aggregate loading capacity of 368,500 bbl. It is estimated that it will then be possible to handle 100,000 bbl. a day from this field.

The East Coast Oil Co. has completed 8 miles of the 24 miles of

8-in. pipe line under construction from Panuco to their terminal near Tampico. They are now testing the section from Panuco to Ponce. English capital is financing the construction of the railroad from Panuco to La Barra. Favorable progress is being made according to recent reports.

Topila, Chijol, Ebano, Caracol Fields.—With the exception of Panuco, the principal activity in the northern districts has been at Topila. This pool continues to be spotty with considerable salt water. Alex Smith and associates brought in a good well during the latter part of 1913 but it soon declined. The Caracol district has not brought in a producer as yet. Ebano and Chijol are still furnishing relatively small amounts of heavy oil.

Central District.—Another good pool has been tapped by the Pearson Co. 3 miles southwest of Juan Casiano. This area is known as the Los Naranjos camp, and has recently developed two good wells, one of 5000 bbl. and the other of 10,000 bbl. daily capacity. Construction is being rushed on the narrow gage railroad and pipe line from San Sebastian to these wells. Two dry holes were also drilled but new locations have been made for wells 5, 6, and 7.

Southern District.—The principal event of the year in the district south of Amatlam was the drilling in of well No. 2 of the Penn-Mexican Fuel Co. on the Alamo property. This came in as a 20,000-bbl. well, No. 1 was a 2000 bbl. well, and Nos. 3 and 4 are shut down awaiting the completion of their pipe line.

Pearson's No. 4 at Potrero del Llano has broken out at various places in the vicinity following an attempt to shut in this gusher after the activity of the Constitutionalists in that district in December, 1913. This well is reported to have a marked influence on wells 4, 6 and 9 on their Alazan lease.

Persia.[1]—Oil prospects had been known to exist in Persia for many years, but not until 1903—when the First Exploitation Co. (Ltd.) was incorporated in England, capital $3,000,000—were any steps taken to develop the oil fields. In 1909 two more companies were incorporated in England; The Bakhtiari Co. (Ltd.), capital $2,000,000, and the Anglo Persian Oil Co. (Ltd.), capital $10,000,000. The first two named are producing companies working in agreement with the third.

The oil fields are connected with the Anglo Persian Oil Co.'s refinery at Abadin, near Mohammarah, one of Persia's principal ports, by a 200-mile pipe line. The refinery is entirely under British management with a British superintendent and employs mainly native labor. In 1912 only five wells were being operated, but a large number were capped

[1] *Daily Consular and Trade Reports.*

and ready for production when needed. The enterprise is only now entering upon the stage of completion and it is expected will shortly be in full operation.

In October, 1913, a shipment of oil was made from Mohammarah to Karachi. This appears to have been the first shipment of oil of any importance from Persia.

Peru.—The petroleum industry developed only in the northern coastal region, receiving considerable stimulus through the entry of the Standard Oil (which controls about 95 per cent. of the country's production) and the growing demand for the product. The output for 1913 will probably be near 3,000,000 bbl. The Standard Oil controls the Lobitos Oil fields' output and through purchase, the controlling interest in the London & Pacific Petroleum Co., Ltd., and the Lagunitos Oil Co. The West Coast Fuel Co., Ltd., is the selling agent and is also controlled by the Standard Oil Co. The only independent producer was Faustino G. Piaggio & Co., Ltd., with a production of about 110,000 bbl. annually. Oil lands were withdrawn from denouncement; several localities, taken up prior to this decree, were being drilled by local capital.

Roumania.—The production for 1913 in Roumania is estimated at 1,885,225 metric tons. According to official returns, the total Roumanian production of crude oil amounted during the first 6 months of the year to 962,892 metric tons, against 862,305 in the corresponding period of 1912. As usual the Parahova district supplied the bulk of the output—viz., 865,545 metric tons (against 758,931). Especially noticeable is the increase in the Moreni production, which rose from 380,583 metric tons in 1912 to fully 502,369 metric tons, or nearly 33 per cent. The Bustenari-Calinet and Gropi-Chiciura wells increased their output from 115,451 metric tons to 121,614 metric tons, but the Campina bores show the heavy decline from 160,405 metric tons to 31,816 metric tons. In the Dambovitza, Buzen and Bacau districts the aggregate production advanced from 862,505 metric tons to 962,982 metric tons in despite of the serious decline in the Dambovitza district from 48,887 to 19,011 metric tons.

As regards the proportions contributed to the total output by the large joint-stock companies, the two most important, the Astra Romana and Steana Romana, show a not immaterial decline against the first half of the preceding year, the exact figures being—for the former concern 221,360 metric tons against 270,300, and for the latter 206,371 metric tons against 217,019. The Romana Americana, on the other hand, advanced from 101,293 metric tons to 146,390 metric tons; but the Concordia receded from 88,530 to 40,113 metric tons, and the Internationale from 49,292 to 19,005 metric tons. The Colombia output,

owing mainly to the supply contributed by the monster bore in its area, rose from 14,424 metric tons to 158,715. The Orion produced 32,575 metric tons (against 35,637), Trajau 13,158 (14,127), Alfa 13,470 (8778), Roumanian Oilfields, Ltd, 27913 (16,361), Aquila Franco-Romana 9516 (7791), Naphtha 8272 (7713), Anglo-Roumanian Petroleum Co., Ltd., 4266 (6785).

The following table shows Roumania's exports of petroleum and petroleum products during the period under review compared with the corresponding period of 1912:

	1913 Metric Tons.	1912 Metric Tons.	Increase in 1913 Metric Tons.
Crude petroleum	20,104	145,700	72,001
Residues	193,903		
Mineral oils	3,694		
Luminant oil	230,429	138,521	91,908
Benzine	99,584	67,397	32,187
Paraffin	363	355	8
Total	548,077	351,973	196,104

Russia.—The total production of petroleum in Russia for 1913 was 69,450,841 bbl. or 9,474,876 metric tons, an increase over 1912 of 1,431,633 bbl. or 2.1 per cent. as shown by the following table:

PRODUCTION OF PETROLEUM IN RUSSIA 1910–1913 BY FIELDS.

	1913 Bbl. 42 gal.	1912 Bbl. 42 gal.	1911 Bbl. 42 gal.	1910 Bbl. 42 gal.
Baku & District	57,174,000	56,872,828	54,828,598	61,206,293
Grozny	8,721,791	7,851,140	9,026,361	8,889,359
Tcheleken	1,905,800	1,600,000	1,225,200	1,180,130
Maikop	586,400	1,104,442	952,453	156,640
Ferghana	549,750	472,785	354,772	118,013
Ural-Caspian	513,100	118,013	.....	.....
Total	69,450,84	68,019,208	66,387,384	71,550,435

Although the production in 1913 exceeded that of 1912 and 1911, it was less than the production of 1910 and 14,008,539 bbl. less than the production of 1901. At that time only two districts were operating—Baku and Grozny, as compared with six in 1913, the number of wells under exploitation then was one-tenth of the present, and their average depth one-third, while 42 per cent. of all the petroleum then produced came from flowing wells as against barely 1 per cent. from such wells to-day. These figures speak for themselves and show what Russia has lost in the last 12 years.

Features of especial interest which developed during the year were the abnormally high price of oil, the Baku-Grozny strike, and the marked decline in the production of several prominent fields.

As high as $20 a metric ton or $2.73 a barrel was paid for crude petroleum in 1913. Such a price was due undoubtedly to the petroleum trust formed with the object of controlling and regulating the market. On August 22, the Russian government instituted a program to prevent a monopoly by removing the import duty on foreign oil to be used by one private and several governmental railroads. The Transcaucasian State Railways purchased immediately 300,000 bbl. of Mexican oil delivered at Batum for $1.72 a bbl. The Mexican Co. has offered to supply the Transcaucasian Railroad with 2,000,000 bbl. a year at the same price and consequently the railroad management has petitioned the government to extend the period of duty free oil for another year.

In a further effort to maintain the price of crude petroleum at a normal level, the Ministry of Trade and Industry is receiving all royalties in the form of oil with the intention of placing the same on the market after the government has reserved that amount deemed necessary for its use. The government is planning to exploit allotments that it still controls and the Ministry of Trade and Industry has completed a draft of laws governing trusts and agreements partaking of the nature of syndicates.

The most serious and widespread strike in the history of the Russian petroleum industry was begun in the Baku field during July, 1913, and extended to Grozny in August. The workmen asked for higher wages, which were refused by the companies despite the advantageous prices which had been secured for petroleum during the preceding 6 months. A serious oil famine was threatened as a result of the strike owing to the enormous curtailment in production. Meanwhile the price of petroleum was again sharply advanced.

In reviewing the operations in the various fields, a few significant features are to tbe noted as follows:

Baku.—During the first half of the year, the production of the four principal Baku fields, Balakahny, Saboonchy, Ramani, and Bibi-Eibat, exceeded slightly that over the corresponding period in 1912. The production declined rapidly in July and August, however, as a result of the strike of the workmen. The shortage of oil due to this curtailment in operations is estimated at 1,500,000 to 2,000,000 bbl.

The *Petroleum World* of London gives the yearly production of Surakhani, the fifth Baku field, as 41,810,328 poods or 5,019,243 bbl. Since the output for 1912 was 3,726,572 bbl., this field shows an increased production of 1,292,671 bbl. or 33 per cent. This gain combined with the increased output of the numerous secondary fields more than offsets the loss due to the strike and gives a total production for Baku and the

surrounding district equal to 57,174,000 bbl. as compared with 56,872,828 bbl. in 1912, an increase of 301,172 bbl. or one-half of 1 per cent. There has also been marked activity in the further exploitation and development of the four principal Baku areas during the past year. The December field report in *Petroleum World* states that there are 2843 producing wells with an average daily yield of 48 to 50 bbl. per well. At the close of 1913 there were 286 new wells drilling.

In the Keleezensk and Nederzenden fields, which were explored, oil was struck at depths varying from 400 to 1000 ft. but the production was very limited and payable oil is doubtful. The work of reclaiming 108 acres of the oil-bearing area of Bibi-Eibat Bay was to have been completed in July, 1914, but the contracting company has notified the Russian Government that the work cannot be finished until July, 1916, and has asked a higher price which the government is not disposed to grant. With the gradual decline in the Baku fields, Balakhany, Saboonchi, and Ramani, the delay in reclamation presents a serious aspect.

The suppression of the import duty has failed to exert any lasting influence on the petroleum market. As a result of the strike, the price advanced to a maximum of $2.75 a barrel in September, then dropped to $2.06 in October, and finally broke to $1.88 per barrel. The cessation of the strike and the close of navigation on the Volga river are the reasons for such a decline in price.

Baku exports for the 12 months ending December, 1913, as compared with the corresponding period in 1912 are as follows:[1]

	Illuminating Oil	Lubricating Oil	Residuum	Crude	Benzine-gasoline	Total
1913.....	10,228,788	2,821,638	24,015,207	6,854,070	407,164	44,326,867
1912.....	10,471,568	2,708,380	24,744,233	6,062,739	223,360	44,210,280

Grozny.—Despite the strike, Grozny produced 8,721,791 bbl. of crude oil in 1913, a gain of 870,651 bbl. or 11 per cent. Several gushers were brought in during the year, one in January at 1856 ft. yielding 7000 bbl. daily for a short period. The North Caucasian Oilfields Co. struck a gusher at Belekfield at 1780 ft. which yielded 1500 to 2000 bbl. daily for a period of 2 months.

Throughout the, year there was great activity in drilling. The *Petroleum World* reports 295 producing wells at the close of December, an increase of 60 per cent. over 1912, which accounts for the increased production. On January 1, 1914, 111 wells were being drilled. The

[1] In barrels of 42 gal.

Spies Co., Akhverdoff & Co., Russian Standard, Kalkhida and Nepht companies also began active exploration work for new wells in the Voznesensky field during the latter half of 1913.

Tcheleken.—Although an increased production over 1912 equal to 305,800 bbl. has been reported for this island, the boring operations during 1913 were reduced 50 per cent. This oilfield has failed to justify the hopes reposed in it.

Maikop.—The enormous decline in the production of this field, amount to nearly 50 per cent., is one of the most significant features in the yearly analysis of the Russian petroleum statistics. The output of Maikop was greatest in 1912 which year proved to be the turning point, however, and since then the monthly production has declined so regularly and persistently as to suggest only one conclusion—the approaching exhaustion of the field. This decline has persisted despite the increase in the number of productive wells and the increased exploitation of the area. The boring work done in the western part of the oilfield has not disclosed petroleum in commercially significant quantities. The daily average of 110 wells over the entire area has been 1 1/2 to 2 metric tons or 11 to 15 bbl. per well. Not only has the yield per well been poor but the beds producing heavy petroleum have displayed a tendency to dry up quickly. Maikop has been another field which has failed to justify expectations and the general decline in activity, extending almost uniformly over the entire region, seems to be an unquestionable sign of the approaching exhaustion of the oil-bearing horizon.

Ural-Caspian.—The results obtained in this area during the past year indicate excellent future possibilities. A gain of 395,087 bbl. or 335 per cent. over the corresponding period in 1912 is largely the result of extended and successful exploitation of this region. The territory to the north of the older locations, although spotted in character, gives promise of further development. Pipe lines have been laid to the Caspian Sea. The Ural-Caspian Corporation and the Emba Co. brought in several flowing wells during the year.

Philippines.[1]—The existence of petroleum seeps on Bondoc peninsula, Tayabas Province, became generally known soon after the American occupation of the Philippines, although no mention of petroleum in Tayabas appears in the geological and mining publications of the former Spanish government. Within the past few years a number of companies have been organized and claims have been located far and wide throughout the region, but development has not gone further than the drilling of two shallow wells. Each of these developed oil, but neither yields a quantity great enough to class it as successful. However, the wells are

[1] Abstracted from Press Bulletin No. 17, Bureau of Science, Government of the Philippine Islands.

close together and neither is more than 325 ft. deep. This vicinity might be made to yield oil in commercial quantities under proper treatment, although it probably could not be considered the most favorable from a geological standpoint. That the wells were not successful therefore, fails as evidence upon which to condemn the whole field.

The presence of petroleum is indicated by seeps of gas and oil at widely separated points throughout the region. The seeps occur invariably near the crests of anticlinical folds and always at about the horizon of the Bacau shale. In several instances the oil oozes directly from the Bacau shale, but in at least one case it appears to come from the upper Vigo shale. Gas, unaccompanied by oil, is emitted at a number of places. No discoloration of the strata by the escaping petroleum can be detected, but the odor of light oil is noticeable in the neighborhood of a petroleum seep. The wells which have been drilled obtained their oil from the Bacau shale. The petroleum contains an unusually large percentage of light oils. Its specific gravity averages 0.832, and distillation gas 30.4 per cent. gasoline, 50.9 per cent. kerosene, 15.1 per cent. heavy oil, these by volume, and 3.6 per cent. residue by weight.

The existence of petroleum on Bondoc peninsula is established, although the quantity which may be available is undetermined. If no petroleum exists other than the small quantity which occurs in the Bacau shale, commercial production is not likely to develop, but if the unexposed lower Vigo strata also contain oil, the prospect is bright. The character of the Vigo shale (alternating shale and sandstone) is favorable for the accumulation of any oil that may be present.

Trinidad.—It is hoped that Trinidad may become an important source of oil for the British Navy. On Nov. 18, 1911, a well was finished which it was estimated produced 25,000 bbl. in 31/2 hours. Many wells sunk to depths of 900 to 1500 ft. have given initial flows of several thousand barrels daily, and several wells have yielded 10,000 to 15,000 tons of oil in the course of a few months. At the end of 1912 ninety wells had been drilled and the 1912 exports amounted to 250,000 bbl.

Turkey.—Practically all the petroleum lands belong to the government which has issued very few permits for propsecting. What few oil wells that have ever been discovered throughout the Empire have never been operated seriously.

Indications of petroleum in Asia Minor are found distributed over most of the peninsula. The most persistent are those which cover practically the two provinces of Moussoul and Bagdad, and to a certain extent the province of Bassrah. The inhabitants have collected the oil for some thousands of years for lighting and medicinal purposes, and deposits of asphalt and bitumen have been used in building operations

from time immemorial. Ancient writers refer constantly to the existence of oil in this part of Asia Minor.

The oil seepages are about two hundred in number and are found in forty different localities, which will give some idea of the amount of territory involved. Roughly speaking, there appear to be four distinct anticlinal lines running practically parallel to each other.

Bibliography

Arnold, Ralph and Garfias, V. R.—The Cementing Process of Excluding Water from Oil Wells as Practised in California. *Tech. Paper No.* 32, Bureau of Mines.

Ball, Lionel C.—Kerosene Shale in Queensland. *Queensland Gov't. Min. Jour.*, April 15, 1913, p. 189.

Bartel, Bohring E.—Die Maikoper Erdolindustrie. *Zeit. Internat. Vereins Bohring. & Bohrtech.*, Feb. 15, 1913, p. 46.

Bec.—Aus der österreichischen Petroleumindustrie. *Chemiker & Tech. Ztg.*, May 15, 1913, p. 78.

Burroughs, William G.—The Pittsfield Oil Field. *Min. Mag.*, Nov., 1913, p. 354.

Cadell, H. M.—Scottish Shale Oil Industry. *Petr. World*, May, 1913, p. 228.

Chambers, D. M.—Die Erdolgewinnung in Italien. *Zeit. Internat. Vereins Bohring. & Bohrtech*, Feb. 1, 1913, p. 31.

Cholmeley, N. G.—The Oil Fields of Burma. *Petr. World.*, May, 1913, p. 221.

Clarke, E. de Courcy.—The Taranaki Petroleum Field, N. Z. *Min. Jour.*, Feb. 8, 1913, p. 133.

Cochrane, T. G, and Redwood, I. C.—Notes on Modern American Oil-field Practice. *Petr. World*, Dec., 1913, p. 572.

Craig, E. H. Cunningham.—The Oil Fields of Barbados. *Petr. World*, July, 1913, p. 316.

Dinsmore, Chas. A.—Deep Drilling in the Artesia Oil field, New Mexico. *Min. Eng. World.*, April 19, 1913, p. 756.

Donath, Ed., and Hofer, H. V.—Das Erdolvorkommen in Raibl. *Petroleum*, Aug. 20, 1913, p. 1493.

Frentzol, Alexander.—Die Erdol Bitumen und Schwefellager von Tetjuschi. *Petroleum*, June 4, 1913, p. 1121.

Hager, Dorsey.—Geological Factors in Oil-well Drilling. *Oil Age*, Mar. 21, 1913, p. 5.

Hauptick, E. de.—The Oil Outlook in Russia. *Min. Jour.*, Oct. 18, 1913, p. 983.

Hauptick, E. de.—'Russian Petroleum Industry. *Min. Jour.*, Sept. 13, 1913, p. 871.

Hilman, C.—Petroleum Developments in Argentina. *Oil Age*, July 11, 1913, p. 2.

Hornaday, W. D.—The Juan Casiano Oil Field, State of Vera Cruz, Mex. *Min. Eng. World*, Jan. 18, 1913, p. 100.

Jamison, C. E.—The Douglas Oil Field, Converse County, Wyoming. Wyoming State Geologist, *Bull.* 3, *Series B.*)

Jamison, C. E.—The Muddy Creek Oil Field, Carbon County, Wyoming. Wyoming State Geologist, *Bull*, 3, *Series B.*

KANTOROWICZ. H.—Ueber Erdol und Erdwachs. *Chemiker-Ztg.*, Nov. 13, 1913, p. 1394.

KORZOUKIN, I. A.—Russia's Petroleum Industry. *Oil Age*, April 25, 1913, p. 6.

MALCOM, WYATT.—Oil and Gas Prospects of the Northwest Provinces of Canada. *Memoir No.* 29-E, Canada Dep. of Mines, Geol. Surv.

OHERN, D. W.—Ponca Oil and Gas Field, Oklahoma. *Nat. Gas Jour.*, Apr., 1913, p. 169.

PADCOE, E. H.—Die Oelfelder von Birma. *Chemiker & Tech., Ztg.* Oct. 15, 1913, p. 153.

PRUTZMANN, PAUL W.—Petroleum in Southern California, 1913. *Bull.* 63, State Mining Bureau of Calif.

R. B. and F. N.—Aus der russischen Erdolindustrie. *Chemiker & Tech. Ztg.*, May 15, 1913, p. 78.

ROGERS, A. P.—The Byron Oil Field, Wyoming. *Eng. Min. Jour.*, Nov. 8, 1913, p. 869.

SMITH, J. T.—The New Oil Fields of the World. *Petr. World*, Oct. 1913, p. 485.)

WILSON, H. W.—Mexico's Oil Industry. *Petr. World*, Aug., 1913, p. 372.

WOODRUFF, E. G.—Geology and Petroleum Resources of the De Beque Oil Field, Colorado. *Bull.* 531-C, U. S. Geol. Surv.

————. A Year's Development of the Trinidad Petroleum Fields. *Petr. World*, Nov., 1913, p. 523.

————. Die Erdolfelder von Birma. *Chemiker & Tech. Ztg.*, Nov. 1. 1913, p. 163.

————. Die Kaukasische Petroleum-Industrie. *Chemiker & Tech. Ztg.*, Sept. 1, 1913, p, 130.

————. Die Welt-Roholproduction. *Petroleum*, March 5, 1913, p. 732.

————. Die Zukunft der Galizischen Erdolindustrie. *Chemiker & Tech. Ztg.*, May 15, 1913, p. 73.

————. Exploitation of Petroleum Springs in Greece. *Min. Eng. World*, Mar. 1, 1913, p. 442.

————. Le Petrole en Roumanie. *Le Petrole*, June 20, 1913, p. 3.

————. L'Exploiration Petrolifere dans L'Argentine. *Le Petrole*, Aug., 1913, p. 5.

————. Oil in the British Empire. *Petr. World*, London, Mar., 1913, p. 121.

NATURAL GAS

Directly associated with petroleum is the production of natural gas. The value of the production has been increasing rapidly year by year, and now amounts to almost a hundred million dollars annually in the United States alone.

From the very nature of the product, figures on production are difficult to secure. The following notes cover most of the important producing states.

California.—According to F. McN. Hamilton, state mineralogist, nearly 50 per cent. of the natural gas of California is not measured since a large proportion is used for fuel at the wells. A close estimation

of the production for 1913 is therefore impossible at this time although the yield will probably exceed that of 1912 and will undoubtedly reach a value of $1,250,000 to $1,500,000 as compared to 9,354,428,000 cu.ft.[1] valued at $1,134,456 in the preceding year.

The increasing quantity of casing head gas treated for gasoline and the transportation of natural gas by pipe line from the Midway field to the city of Los Angeles and vicinity were features of especial interest. The Midway Gas Co. is now able to supply 24,000,000 cu. ft. of gas per day to consumers in Los Angeles.

The Union Oil Co. added a second unit to its gasoline plant on the Newlove lease in the Santa Maria field. This plant now has a capacity of 7,500,000 cu. ft. of gas daily from which 7000 gal. of gasoline are extracted. The gasoline is mixed with toppings of crude oil to reduce its grade sufficiently for commercial purposes. In this manner, 7000 gal. of casing-head gasoline yield 14,000 gal. of commercial product daily.

Colorado.[2]—The greater part of the natrual gas in Colorado comes from the oil-producing fields, Florence and Boulder. A portion of the product from the latter area is used for lighting and domestic purposes by the residents of Boulder. The production from this field for 1913 is 75,755,000 cu. ft. of which 23,000,000 cu. ft. was used for domestic purposes and 52,755,000 cu. ft. for power and the abstraction of naptha. The value of the natural gas used domestically was $23,000. Two thousand eight hundred and fifty-six barrels of naptha were obtained from the treatment of casing-head gas. This naptha sold at prices varying from $2.52 to $4.20 per barrel with a total value of $9,455,00 for the Boulder County output.

The gas from the Florence field is not metered but is used directly under boilers for pumping and drilling. Recently considerable natural gas from this area has been treated for its gasoline content but such quantities of gas are not measured but estimated from the amount of naptha produced.

Kansas.[3]—Considerable of the natural gas consumed by Kansas is piped in from Oklahoma. The gas situation throughout the Kansas field was in an unsatisfactory condition during 1913. The litigation begun in 1912 is still unadjusted. Two groups of receivers have been appointed to handle the affairs of the Kansas Natural Gas Co. whose property has been so tied up by the courts that no extra development work and pipe-line extensions could be undertaken during the past

[1] Mineral Resources of U. S., 1912, Natural Gas, B. Hill.
[2] From data and information supplied by R. D. George, State Geologist, Boulder, Colo.
[3] From "Oil and Gas in the Midcontinental Field" by Erasmus Haworth, *Eng. Min. Jour.*, Jan. 7, 1914.

12 months. "The amount of gas piped to the northern cities, St. Joseph, Kansas City, Atchison, Topeka and others, has been unsatisfactory and great complaint has resulted. Many Oklahoma and Kansas producers insist that the nes Oklahoma developments have produced enough gas to last the northern cities indefinitely, but there are few new wells to which pipe lines have been laid. Moreover, in almost every instance where new gas wells have been tapped with pipe lines, the wells have proved unsatisfactory and short lived. Such a rapid decline of large wells is without precedent."

Ohio (By J. A. Bownocker).—The year as regards natural gas has been almost as uneventful as in oil. The only large source of gas in Ohio is the "Clinton" sand in which gas was discovered in 1887. The productive territory now extends from Knox County south the Hocking with a large ares farther north in Ashland and less important fields in Wayne, Medina, and Lorain Counties. During 1913 the best results were obtained in the Ashland County field where the new wells averaged about 2,000,000 cu. ft. per day at the start, at Alexandria, Licking County, and along the southern border of the field in Hocking County. Strenuous efforts have been made and are still being made to extend the gas fields in this formation but the results have not been satisfactory and Ohio will have to rely more and more on West Virginia for her natural gas supply. The production in Ohio is now probably at its maximum.

In 1912 natural gas was found in the "Clinton" sand along the western border of Cleveland and the drill has been busy since that time. Thrity-five wells had been sunk in that locality by February, 1914, and only four were failures. The largest had an open flow at the start at the rate of 5,000,000 cu. ft. per day and a closed or rock pressure of 1100 lb. Many strings of tools are at work and the number of wells sunk in 1914 will be large.

The daily production of this field at the close of 1913 was about 12,000,000 cu ft. Wells have been sunk much too close together, however, and the decrease of the wells is sure to be rapid. On February 2, 1914, the Stadler well, in the valley of the Cuyahoga within the city limits, started flowing at the rate of 10,000,000 cu ft. per day. The gas was not found in the "Clinton" but in a sand imbedded in the Silurian limestones about 300 ft. above the "Clinton."

Oklahoma.—The advance press bulletin issued by the Oklahoma Geological Survey estimates the natural gas production in 1913 at 80,000,000,000 cu. ft. valued at $8,000,000, an increase of about 9 per cent. and $600,000 respectively over 1912. The quantity and value of the natural gas produced in Oklahoma since 1910 is as follows:

Year	Production in cu. ft.	Value
1910	50,430,000,000	$3,490,704
1911	67,276,000,000	$6,731,770
1912	73,800,000,000	$7,406,528
1913	80,000,000,000	$8,000,000

The development of the natural gas resources of the state has been in a large measure incidental to the oil development. With the increased activity in drilling operations which characterized the oil exploration during 1913, the number of new gas wells reported was not unexpected. Where pipe lines have been laid to these wells, however, the latter have proved unsatisfactory and short lived in many instances.

A remarkable gas pool was tapped near Dewey in May and produced wonderful wells. One of them started with a capacity of over 46,000,000 cu. ft. per day and others gave 20,000,000 or better. About 16 or 18 wells were drilled in rapid succession, 9 or 10 of which were producers. Pipe lines were connected but in 3 or 4 months the wells were exhausted, having produced little, if any, more than gas enough to pay for the drilling. So rapid a decline of such large wells is almost unprecedented.

Several excellent gassers were tapped from the Cushing pool which continues its wonderful production. Great interest has been manifested in the number of new wells brought in at the Loco, Duncan, and Healdton pools in the southern part of the state. Development in this region has proceeded far enough to assure an ample supply of gas for the surrounding towns for several years to come. The Ardmore Gas Co. has completed arrangements to lay 9 miles of line to the gas wells in the Healdton field.

About 50 per cent. of Oklahoma natural gas is exported to Kansas and Missouri and the remainder is consumed within the state for domestic and industrial purposes.

Pennsylvania (By Richard R. Hice).—Excluding the small gas wells used locally in Erie County there were at the close of the year 1912, 11,041 producing gas wells in Pennsylvania. This does not include many oil wells, which produced "casing-head" gas, used in operating wells, for gasoline, etc. The wells are owned by 703 operators, but many of the smaller producers sell their gas to the larger distributing companies. The total value of the gas produced in 1912 was $18,539,672.

It is impossible to make any definite estimate of the quantity of gas produced in 1913 until all reports are received and tabulated. The value of the production is about the same as for 1912. There is no record kept of the wells drilled especially for gas. The *Oil City Derrick* reports 308 of the wells drilled for oil as being gas wells, this, however, represents but a portion of the gas wells. If the wells thus reported bear the same relation to the entire number of gas wells as during the year 1912, the total new

wells producing gas in 1913 would be 980 as against 774 gas wells completed in 1912.¶

The production of the wells is gradually declining and the new wells brought in are quite small as compared with the wells of some years ago. Therefore the relative investment in distributing lines is larger not to speak of the increased cost of operation in the way of the necessary pump stations and the expense attending them.

West Virginia (By I. C. White).—During the year 1912, West Virginia marketed in round numbers 239,084,000,000 cu. ft. of natural gas of a value amounting to $33,349,000, while at least that much more was wasted into the air and burned unmetered. The average price obtained in 1912 was 13.95 cents per thousand cubic feet, as against 13.74 cents in 1911, when 206,890,500,000 cu. ft. were produced, valued at $28,436,000. The exact production figures for 1913 are not yet at hand, but it is probable that the increase over 1912 was at least 10 per cent., since the latter year increased 15 per cent. above the production for 1911, and hence the amount marketed from West Virginia in 1913 would probably be somewhere between 260,000,000,000 and 270,000,000,000 cu. ft. with a value approaching $40,000,000.

Practically all of the state west from the mountain region, and containing more than half its area, produces natural gas in commercial quantity, including 32 counties.

Many new gas wells are drilled every month in West Virginia, and several new pools, or spurs from old ones, are discovered every year, so that the supply, if utilized only for domestic purposes (as it should be) would probably continue to furnish a large quantity for more than 50 years in the future.

Gasoline.—The gasoline industry in West Virginia has largely increased during the year 1913, and the state still remains at the head of the column in this respect, producing nearly as much gasoline manufactured from natural gas as nearly all the rest of the states of the Union together. The production of gasoline from natural gas in West Virginia during the year 1912 from 97 plants, was 5,318,136 gal., valued at $513,116, or a price of 9.6 cents per gallon from an estimated quantity of nearly 2,000,000,000 cu. ft. of gas, yielding an average of 2.8 gal. per thousand cubic feet. It is certain that the production was larger than this in 1913, but just how much larger cannot be determined until the full statistics are compiled.

Foreign Countries

Austria-Hungary.—The natural-gas occurrences lately discovered at Wels, in Upper Austria, have been subject of very careful examination

by Mr. Werndl, who publishes the results in the *Berg- und Hüttenmännische Rundschau.* As regards chemical composition the gas is almost identical with that of Neuengamme, near Hamburg, the methane contents being in both cases 91.5 per cent. Though the discovery of the gas is of comparatively recent date, several manufacturing concerns in the neighborhood of Wels are already supplied with power by the existing wells. Its calorific value is high, the cubic meter being equal to 8321 Cal., which means that the gas would be suitable for metallurgical purposes. The Austrian government is actively engaged in further exploring the ground.

The boreholes pierced in Hungary in search of potash have proved barren of that substance, but have, as is known, resulted in the discovery of large volumes of pure natural gas, says the *Mining Journal,* Sept. 13, 1913. M. Herbing, in *Zeitschrift für angewandte Chemie,* gives the following particulars. The first borehole was sunk at Kissarmus, in Transylvania, and continues to discharge the gas with the same energy as during the past 2 years, which appears to confirm the opinion of the existence of an extensive area of productive strata. Geological investigations have shown that the presence of gas is associated with an anticlinal 50 miles long, and that the strata, so far from being undisturbed, as was supposed, are considerably folded. Escapes of natural gas from streams and ponds are frequent, and the occurrence at Kissarmus may not be singular, since tectonic considerations render it probable that rocks throughout the province are permeated by the gas. From the commencement the first bore yielded about 800,000 cubic meters of gas with 99 per cent. of CH_4, but after a gas explosion in a neighboring work it increased to a million in 24 hours. From five other boreholes, whose depths varied from 220 to 720 ft., were obtained from 36,000 to 210,000 cubic meters or a total of 431,000 in 24 hours, which, with other wells, reached 440,000 per diem. As the abundance of gas is in relation to depth, the yield can be enhanced by deepening the bores should they show symptoms of abatement. The output of the principal borehole could be conveyed by piping—280 miles—to Buda-Pest for an estimated outlay of £846,000. This city burns 300,000 cubic meters of gas daily, and the cities situated along the route would easily absorb the surplus. Observing what is taking place with natural gas in America, there is no doubt that Hungary will profit by the use of this fuel during a long future.[1]

The Hungarian Minister of Mines has stated officially that, up to the present, seventeen borings have been made in Transylvania which furnish natural gas, the total daily amount reaching 2,650,000 cu. yd. These borings have been carefully plugged so as to avoid any loss of gas.

[1] *Eng. Min. Jour.*, Dec. 13, 1913.

The exploring operations, so far, have been limited to four districts in Transylvania, though it is known that gas has been recognized in at least twenty-seven other districts. A pipe line 32 miles long is in course of construction to Thorenberg, which will be completed in the autumn, and will supply the natural gas to the industrial works of that place. The Hungarian Minister of Finance has received numerous offers from manufacturers desiring to use it.

Canada.[1]—There was comparatively little change in the production of natural gas in Ontario but a large increase in the production in New Brunswick and in Alberta. The total production of 1913 was approximately 20,345,000,000,000 cu. ft. valued at $3,338,314 of which 828,000,000,000 ft. valued at $174,006 was from New Brunswick, 12,487,000,000 ft. valued at $2,092,400 from Ontario and 7,030,000, ft. valued at $1,071,908 from Alberta.

The production in 1912 was reported as 15,287,000,000 cu. ft., valued at $2,362,700 and included 174,000,000 cu. ft. from New Brunswick valued at $36,549; 12,529,000,000 cu. ft. from Ontario valued at $2,036,245 and 2,584,000,000 cu. ft. from Alberta valued at $289,906.

Bibliography

Arnold, Ralph and Clapp, F. G.—Wastes in the Production and Utilization of Natural Gas and Means of Their Prevention. *Tech. Paper* 28, U. S. Bureau of Mines.

Burrell, Geo. A. and Siebert, Frank M.—The Condensation of Gasoline from Natural Gas. *Chem. Engr.*, Sept., 1913, p. 89.

Clapp, F. G.—Outline of the Geology of Natural Gas in the United States. *Econ. Geol.*, Sept., 1913, p. 517.

Gould Chas. N.—The Occurrence of Petroleum and Natural Gas in the Mid-continent Field, United States. *Petr. World*, Sept., 1913, p. 421.

Hood, O. P. and Heggem, A. G.—Proposed Regulations for the Drilling of Gas and Oil Wells, with Comments Thereon. *Tech. Paper* 53, U. S. Bureau of Mines.

Hubbard, Geo. D.—Gas and Oil Wells Near Oberlin, Ohio. *Econ. Geol.*, Oct., 1913, p. 681.

Merrian, E. S. and Birchby, J. A.—Methods for the Examination of Natural Gas for the Production of Gasoline. *Jour. Ind. Eng. Chem.*, Oct., 1913, p. 824.

Munn, M. J.—The Menifee Gas Field and the Ragland Oil Field, Kentucky. *Bull.* 531-A, U. S. Geol. Surv.

Reeser, H. C.—Natural Gas Leakage: Its Cause and Prevention. *Nat. Gas. Jour.*, May, 1913, p. 221.)

Rice, George S.—Gas and Oil Wells in Coal Fields. *Coal Age*, Feb. 22, 1913, p. 292.

Stopnewitsch, A. D.—Erdgas und Erdol im allgemeinen und su Stawropol im besonderen. *Chemiker and Tech. Ztg.*, April 1, 1913, p. 49.

Werndl, F.—Die Naturgase in Wels, Austria. *Berg. and Huttenm. Rundschau*, April 5, 1913, p. 159.

———.Regulation of Natural Gas and Petroleum Production. *Min. Sci.*, May, 1913, p. 270.

[1] Preliminary Report, Mineral Production of Canada.

PHOSPHATE ROCK

By W. H. Waggaman

The annual production of phosphate rock now exceeds 6,250,000 tons; of this amount the United States in 1913 produced 3,062,975 tons and consumed 1,724,525 tons, this continuing to hold its position as the foremost phosphate-producing country in the world.

New deposits of phosphates, however, have been discovered and developed in many other places so that several nations are at present independent in regard to their supplies of this essential fertilizer material. The development of these new deposits together with the introduction of cheaper and more modern mining methods in the older phosphate fields has so increased production in recent years that in some sections the dealers find that the supply of phosphate has grown greater than the demand. Competition therefore has become so keen that a general lowering of prices has resulted and during 1913 some rock was actually sold at less than it cost to produce. Such practice is much to be regretted since it has a very demoralizing effect on the market and the whole phosphate industry. Practically all the phosphate rock marketed is treated with sulphuric acid (an equal amount of weight approximately) and manufactured into acid phosphate for the fertilizer trade. In the United States, however, particularly in the middle West a small percentage of raw finely ground rock phosphate is used directly on the fields. The amount of phosphate thus consumed during 1913 was 43,908 tons. Numerous processes for producing soluble or available phosphates without the use of sulphuric acid have been proposed and patented from time to time and some of them give promise of being commercially practicable. The percentage of phosphate rock consumed by such processes, however, is as yet nearly negligible. Brief descriptions of several of these schemes are given further on.

Taking up the phosphate deposits of the various countries in the order of their present commercial importance they are as follows:

The phosphates of the United States including those of great value and extent in Florida, Tennessee, South Carolina and the Western States of Utah, Idaho, Wyoming and Montana, and deposits of lesser importance in Kentucky, Arkansas, North Carolina and Virginia; the deposits in Northern Africa in Tunis, Algeria, and Egypt; the deposits of the Pacific and Indian oceans, including those of Ocean, Christmas and Pleasant

Islands and the islands of the Marshall and Society groups; the phosphates of Russia; the phosphates of Belgium and France; the Peruvian guano deposits, and the many smaller deposits in various other countries.

The world's production of phosphates is given in Table I.

TABLE I.—PRODUCTION OF PHOSPHATE IN THE WORLD.
(In metric tons.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Algeria	333,531	315,000	452,060	351,491	(d)319,069	332,897	388,515	461,030
Angaur Palan Iseln.	.....	.....	.....	9,000	45,000	41,000	50,000	.....
Belgium	(b)152,140	181,230	198,030	205,260	202,880	196,780	.....	(e)178,455
Canada	930	680	1,622	998	1,341	506	.....	.....
Christmas Island (d).	93,335	110,000	260,000	197,982	310,625	250,000	300,000	(f)150,005
Dutch W. Indies								
Aruba	25,531	36,036	20,061	27,227	27,838	.....	.....	.....
Curacao	11,00	.....	.....	.....	3,570	.....	.....	1,850
Egypt	.....	.....	700	1,000	2,397	6,425	69,958	64,183
France	469,408	375,000	485,607	397,903	333,506	312,204	.....	.....
French Guiana	6,795	10,565	9,092	8,997	6,816	.....	.....	.....
Makatea(d)	.....	.....	.....	.....	.....	12,000	40,000	(c)
Norway	3,482	1,830	1,771	1,364	903	.....	.....	.....
Ocean and Naurn Islands.	140,000	190,000	301,160	197,922	310,625	250,000	300,000	(c)
Russia	13,891	11,290	14,786	12,906	15,293	10,200	.....	.....
Spain	1,300	3,078	4,483	1,387	(d)2,840	3,520	.....	.....
Sweden	(c)	5,317	(c)	(c)	.....	.....	3,292	.....
Tunis	796,000	1,069,000	1,300,500	1,223,512	1,286,262	(a)1,446,633	1,923,000	1,803,564
United States	2,085,586	2,251,459	2,413,032	2,503,186	2,724,849	3,260,626	3,216,046	3,068,604

(b) Metric tons of phosphate of lime; in addition there were 315,200 cubic meters of phosphatic chalk in 1902, 350,250 cubic meters in 1903, 311,640 cubic meters in 1904, 80,380 cubic meters in 1905, and 119,450 cubic meters in 1906.
(c) Statistics not available.
(d) Figures furnished by Charles Michel, Paris.
(e) Exports.
(f) *American Fertilizer.*

The United States

The United States is not only the largest producer of phosphate rock but has a known reserve supply far greater than any other country.

Numerous estimates have been made from time to time on the tonnage of phosphate available for future use in this country but they have varied so widely that little importance can be attached to them. Owing to the irregular character of some of the American deposits accurate estimates can be made only by the most careful prospecting. Such prospecting is frequently not warranted and is seldom done except immediately before actual mining operations are begun.

The data given below, however, were compiled with considerable care from figures obtained by consultation with mine operators and by direct observation and field investigations of the various deposits throughout the country. While they are not intended for accurate estimates they may be regarded as conservative.

The figures represent rock grading from 60 to 70 per cent. bone phosphate of lime. In the case of the low-grade phosphate in the West and the wash heaps of Florida, the material is figured to its equivalent in high-grade rock.

TABLE II.—RESERVE SUPPLY OF PHOSPHATE ROCK IN UNITED STATES (a).

	Tons.
Utah, Idaho, Wyoming and Montana:	
High-grade	2,500,000,000
High-grade equivalent of all grades	7,500,000,000
Florida:	
High-grade equivalent of all grades	354,300,000
High-grade equivalent of wash heaps	20,000,000
Tennessee:	
High-grade equivalent of all grades	115,075,000
South Carolina:	
High-grade equivalent of all grades	10,000,000
Arkansas:	
High-grade equivalent of all grades	20,000,000
Kentucky:	
High-grade equivalent of all grades	500,000
Total	10,519,875,000

(a) Data collected by U. S. Dep't. of Agriculture.

Even assuming that there are no new discoveries in the United States, and that the average consumption during the life of the phosphate fields will be three times its present consumption, there is sufficient to last for over 1100 years provided proper mining methods are employed and means for utilizing the lower grade material are devised.

The production of phosphate rock in the U. S. for the past 4 years, the consumption, and the exports and imports of this material are given in the following tables:

TABLE III.—PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES. (a)
(In tons of 2240 lb.)

	1910.		1911.		1912.		1913.	
Phosphate.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida hard rock	392,088	$2,940,660	474,094	$2,953,606	536,279	$3,218,274	510,811	$3,371,386
Florida land pebble	1,637,709	6,550,836	2,020,477	6,809,007	2,043,486	7,101,186	2,043,403	6,334,549
Florida river pebble	.....	.....	.....	.....	.....	.....	.....	.....
Total, Florida	2,029,797	$9,491,496	2,494,571	$9,762,613	2,579,865	$10,319,460	2,554,214	$9,705,935
S. Car. land rock	185,000	$786,250	(b)169,156	$673,156	(b)131,490	$524,760	.....	.....
S. Car. river rock	16,347	57,314	*nil*	.....	.....	.....	.....	.....
Total, S. Carolina	201,347	$843,564	169,156	$673,156	131,490	$524,760	92,568	$370,272
Tennessee	440,699	$1,586,516	542,761	$1,918,489	443,065	$1,710,000	439,822	$1,649,303
Other States	10,095	40,380	(c) 10,505	39,882	(b)11,612	46,450	(d)	(d)
Total, U. S.	2,681,938	$11,961,956	3,216,993	$12,394,140	3,166,032	$12,600,670	3,093,614	$11,753,510

(a) Statistics collected by MINERAL INDUSTRY, except as otherwise noted. (b) Reported by the U. S. Geol. Survey. (c) Idaho, Utah and Wyoming. (d) Less than in 1912.

TABLE IV.—STATISTICS OF PHOSPHATES IN THE UNITED STATES. (a)
(In tons of 2240 lb.)

Year.	Production.	Imports.	Exports, (b).	Consumption.	Year.	Production.	Imports.	Exports, (b).	Consumption.
1901...	1,483,723	180,714	729,539	934,898	1907..	2,251,459	25,896	1,018,212	1,259,143
1902...	1,600,813	145,793	802,086	944,250	1908..	2,375,031	26,734	1,196,175	1,205,590
1903...	1,581,576	153,972	785,259	950,289	1909..	2,463,766	11,903	1,020,556	1,455,113
1904...	1,874,428	166,090	842,484	1,198,034	1910..	2,681,938	19,319	1,083,037	1,618,220
1905...	1,933,286	82,072	934,940	1,080,418	1911..	3,216,993	16,153	1,246,577	980,569
1906...	2,052,742	46,228	904,214	1,194,756	1912..	3,166,032	28,821	1,206,520	1,988,333
					1913..	3,062,975	26,408	1,338,450	1,724,525

(a) Production statistics of 1901 and subsequent years, except 1905–1913, are those of the U. S. Geological Survey and are based on marketed products. (b) Neglecting the insignificant exports of foreign product.

The imports of fertilizers of all kinds into the United States were as follows:

TABLE V.—IMPORTS OF FERTILIZERS INTO THE UNITED STATES.[1]
(In Tons of 2240.)

	1909.		1910.		1911.		1912.		1913.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Phosphates (crude).	17,398	128,629	17,668	204,340	18,980	203,326	20,685	179,605	23,478	184,204
Apatite	.....	.....	.....	.....	.....	.....	80	1,140	2,930	22,515
Basic slag	51	625	8,856	75,705	13,150	89,175	11,751	110,229	15,124	145,477
Blood char (lb.)	.....	.....	.....	347	661	347	.....	.....	2,954	333
Blood (dried)	.....	91,706	.....	224,381	.....	448,739	.....	220,297	.....	86,065
Blood (dried) (when soluble) lb.	103	60	5,562	351	4,897	280	7,701	423	6,412	339
Bone char	.....	5,481	.....	18,232	.....	22,448	.....	20,414	.....	12,484
Bone dust	22,545	543,048	37,730	882,407	44,635	1,134,443	118,535	913,023	33,919	818,306
Guano	37,014	580,048	46,819	819,879	31,740	625,044	34,856	685,140	16,461	313,898
Kainit	.....	.....	470,241	2,268,363	586,474	2,637,105	479,417	2,400,590	466,184	2,349,689
Keiserite	.....	.....	5,179	10,484	2,100	3,564	7,545	17,689	10,800	44,770
Cyanite	.....	.....	8,735	44,303	400	1,994	900	7,535	612	7,949
Manure salts	.....	.....	90,933	928,357	160,105	1,265,867	185,682	1,824,426	172,557	1,798,973
Potash (muriate)	148,668	4,758,906	195,927	5,640,541	214,284	6,449,575	242,033	7,235,729	223,836	6,737,757
Potash (sulphate)	30,508	1,148,607	24,485	1,399,915	53,139	1,952,370	50,551	1,853,236	48,022	1,798,369
Nitrate of soda[2]	353,557	12,583,416	542,333	16,548,036	546,394	17,101,155	481,786	15,427,904	586,315	20,713,375
All other substances	198,553	2,747,074	196,901	3,129,813	191,975	3,914,508	169,283	3,527,646	115,257	2,190,816

TABLE VI.—EXPORTS OF DOMESTIC FERTILIZER MATERIALS, 1913.[1]

	Tons.	Value.
Phosphate rock, not acidulated:		
High-grade hard rock[2]	473,533	$4,735,330
Land pebble[2]	891,263	5,255,416
All other[2]	1,712	5,834
All other fertilizers	72,747	1,666,755
Exported to:		
Belgium	137,331	855,407
France	120,724	740,482
Germany	348,103	3,018,457
Italy	102,147	635,140
Netherlands	195,675	1,516,047
United Kingdom	179,239	1,158,066
Other Europe	182,037	1,450,538
Canada	39,069	700,654
West Indies and Bermuda	32,849	785,839
Japan	99,255	659,831
Other countries	2,826	112,874
Cottonseed meal	471,016	13,735,835

[1] *American Fertilizer.*
[2] Not separately stated prior to July 1, 1912.

Florida.—The phosphates of Florida still hold first place among the more important deposits known to the world, located in one of the southern states where fully 80 per cent. of the fertilizer manufactured in this country is consumed, and having excellent transportation facilities both by rail and water, they are well fitted to supply our domestic needs. Moreover, their richness and even grade will no doubt continue to afford them a market in European countries for many years to come.

In 1912 according to the State Geologist, thirty companies were engaged in mining operations. The total output for that year was 2,579,865 and appreciable increase over the production of any previous year. In 1913 only twenty-eight companies were actively engaged in mining or shipping rock and the total production based on the material marketed was 2,554,214 tons which is 25,651 tons less than in 1912. This decrease was principally in the hard rock regions.

Hard Rock.—The hard rock phosphate deposits are of tertiary age and lie toward the west side of the Florida peninsula extending in a general north and south direction for a distance of 100 miles. The material is of a very high grade, ranging from 75 to 85 per cent. bone phosphate of lime and for many years was the most eagerly exploited of all the phosphate rock known.

Owing to the pockety nature of the deposits the expense of prospecting for and mining hard rock is considerable, and now that phosphate has been discovered in so many different localities, only the exceptional richness of the hard rock phosphate enables it to successfully compete with the cheaper rock from other sources.

The installation of electric power obtained from the hydro-electric plant of the Florida Power Co. on the Withlacoochee river and the growing use of the hydraulic method of removing overburden has aided materially in reducing the cost of mining hard rock phosphate.

The production of hard rock fell off somewhat in 1913; only thirteen companies were mining or shipping phosphate from these regions, while in 1912 fourteen companies were actively engaged.

The marketed output for the past year was 510,811 tons as against 536,369 tons in 1912, which is a decrease of 25,558 tons.

The actual tonnage produced, however, was much less than that marketed since many operators were only mining intermittently and their shipments were largely made from surplus rock carried over from the previous year.

Mining operations during the early part of 1914, however, were proceeding with renewed vigor. Several new plants were being erected by the older companies while one new concern was planning to begin operations in these fields.

Practically all of the hard rock with the exception of about 13,000 tons was shipped abroad and sold under the usual guarantee of 77 per cent. bone phosphate of lime and a maximum of 3 per cent. iron and alumina. The average price for the year was about $6.60 per long ton at the ports.

Pebble Phosphate.—The pebble phosphate fields which lie to the south of the hard rock regions now far surpass the latter in commercial importance while the two classes of rock belong to the same geologic age the pebble deposits are much more regular in their occurrence and can be more readily and cheaply mined.

With the exception of one company all the operators in the pebble regions employ the hydraulic methods both for removing overburden and mining the rock. Most of the companies are operating several washers but the washed rock is usually hauled to a central drying plant to be dried, stored and loaded for shipment. Day and night shifts are employed throughout the fields.

The pebble phosphate on the whole is of lower grade than the hard rock averaging about 70 per cent. bone phosphate of lime. Several concerns however with exceptionally rich deposits are guaranteeing their product to run as high as 75 to 77 per cent. In 1913 fifteen companies were actively engaged in mining pebble phosphate as against sixteen companies in 1912. The output in 1913 was 2,043,403 practically the same as the year previous when 2,043,486 tons were marketed. During 1913 three large new companies entered the pebble fields, only one of these however had its plant completed in time to produce any rock. It is expected that the other two concerns will be ready to start operations early in 1914.

Most of the pebble phosphate is sold on a guarantee of 68 per cent. bone phosphate of lime and a maximum of 4 per cent. iron and alumina. In 1913 the exports amounted to 865,639 tons, while 1,177,764 tons were consumed in the United States. The average price for the year was about $3.10 per long ton at the ports.

The production of Florida phosphates for the past 5 years is given in Table VII.

TABLE VII.—STATISTICS OF FLORIDA PHOSPHATE.
(In long tons.)

Year.	Production.			Total Shipments.	Domestic Consignment.	Exports.
	Hard Rock.	Pebble.	Total.			
1909	527,582	1,334,569	1,862,151	1,843,203	837,217	1,005,986
1910	392,088	1,637,709	2,029,797	2,081,936	1,014,473	1,067,463
1911	474,094	2,020,477	2,494,571	2,456,440	1,290,779	1,165,661
1912	536,379	2,043,486	2,579,865	2,422,932	1,219,927	1,203,005
1913	510,811	2,043,403	2,554,214	2,554,214	1,130,764	1,363,450

Tennessee.—There are three classes of phosphate in Tennessee, namely, the brown, blue and white rock. Of these the brown and blue have so far proved of the most commercial importance.

The brown rock is of Ordivician age and occurs over a very wide area. The most important localities where mining is now being conducted are in the vicinity of Mt. Pleasant, Maury County, near Centerville in Hickman County and in the vicinity of Wales Station in Giles County. The rock ranges in grade from 55 to 78 per cent. bone phosphate of lime depending on the locality. The average grade is about 72 per cent.

The blue or Devonian phosphate is being mined near Gordonsburg, Lewis County and also in the Centersville region. The average grade of the blue rock is about 70 per cent. bone phosphate of lime.

Deposits of white phosphates occur in Perry and Decatur Counties. Some of this rock is very rich, containing as high as 85 per cent. bone phosphate of lime, but owing to the pockety nature of the deposits the phosphate has not been mined in recent years.

Tennessee is particularly well situated for the distribution of fertilizer material to the South and Middle West but is not as favorably located as Florida for the exportation of phosphate rock. In 1913 ten companies were engaged in mining Tennessee phosphate. Their total marketed output for the year was 439,822 tons, an amount slightly below that of 1912 when 443,056 tons were produced. Practically all of this rock was consumed in the United States and sold for an average price of about $3.60 f.o.b. mines.

During the past few years the mining of brown rock phosphate has undergone quite a revolution. The old pioneer methods have been replaced by modern schemes which not only save more material but have made it possible to profitably rework the old dump heaps and waste ponds. The life of the Tennessee phosphate fields has thereby been considerably prolonged.

South Carolina.—The nodular phosphates of South Carolina formerly the most eagerly exploited deposits in this country, are yearly becoming of less commercial importance. Contrary to general opinion the South Carolina phosphates are far from exhausted, but the expense of mining, and the comparative low content of phosphoric acid in the rocks as compared with the Florida and Tennessee phosphates has discouraged further development in these fields.

The output in 1913 was considerably below that of 1912, when 131,490 tons were produced. The average grade of the rock is 60 per cent. bone phosphate of lime and its price f.o.b. mines is $4.00 per ton.

It is obvious therefore that the rock is unable to compete with the higher grade product from other sources except for local consumption.

Much of the rock is shipped to Charleston and made into double acid phosphate a concentrated phosphate fertilizer.

South Carolina phosphate is mined by first removing the overburden with steam shovels then digging out the phosphatic stratum thus exposed. The material is then loaded onto flat cars and sent to the washer where it is washed, screened and dried.

Utah, Idaho, Wyoming and Montana.—In the Carboniferous rocks of these states are the most extensive deposits of phosphate known in the world.

The rock occurs as a bedded deposit having an oölitic structure and varies in color from gray to jet black. It resembles somewhat the blue rock of Tennessee but occurs in much thicker strata. The average grade of the rock is about 70 per cent. bone phosphate of lime with only a small fraction of a per cent. of iron and aluminium oxides.

In December, 1908, the Secretary of the Interior withdrew from entry 7000 acres of land in this region pending an investigation of its phosphate resources, and in the summer of 1909 the U. S. Geological Survey began an examination of this area. Much of this land has since been restored as non-phosphatic, but large areas not included in the original withdrawals were found to contain phosphate rock and were therefore added to the phosphate reserve.

The withdrawals outstanding June 30, 1913, were 2,922,556 acres in Utah, Idaho, Wyoming, Montana and Florida.

Claims had already been filed, however, on much valuable phosphate land in the above states before the withdrawals were made and most of these claims were granted, so several companies control very rich deposits in Utah, Idaho and Wyoming and are in a position to produce a large tonnage of rock when the market justifies it. At present however the limited use of fertilizer in the Western States and the heavy cost of hauling the material to a more ready market prevent the development of these deposits. In 1913 a few thousand tons of rock were shipped from these states to California and made into acid phosphate. In 1912, a total of 11,612 tons were marketed from the same fields.

The classification of Government lands containing oil, gas, saline, coal, and phosphate rock is the subject of an exhaustive report issued in 1913 by the U. S. Geological Survey.[1]

Arkansas.—The phosphate deposits of Arkansas are not generally regarded as of great economic importance for though limited amounts of rock have been found which contain a high percentage of phosphoric acid, the average grade of the phosphate so far mined is rather low.

Mining has only been conducted to any extent in the northern part of

[1] *Bull.* 537, U. S. Geol. Survey, 1913.

the State in Independence County about 12 miles from Batesville. There the phosphate rock is of Silurian age and occurs as a bedded deposit in two strata, one directly overlying the other. The upper stratum (from 3 1/2 to 6 ft. thick) is the only one considered worth mining and averages about 55 per cent. bone phosphate of lime.

No production has been reported from Arkansas for 1913. The mines near Batesville have been shut down as it has been found cheaper to supply the demand for phosphate just west of the Mississippi from the higher grade deposits of Tennessee.

Kentucky.—Several small deposits of high-grade phosphate rock have been found in the Ordivician limestone in Woodford, Scott, Fayette and Jessamine Counties, Kentucky. A limited amount of development work has been done and a small tonnage shipped from Midway a little town between Frankfort and Lexington, but no production has been reported for 1913.

The Kentucky phosphate occurs in thin close-grained plates brownish gray in color and resembles closely the brown rock phosphate of Tennessee. In order to prepare the rock for the manufacture of acid phosphate it must be put through a washing process similar to that employed in the Tennessee fields. The expense of erecting such a washer is justified only where there are large supplies of rock close at hand so it is doubtful whether the Kentucky fields will be developed to any extent until larger bodies of phosphate are discovered. The rock so far marketed was finely ground and sold for direct application to the field.

Virginia.—The occurrence of phosphate rock at two localities in southwest Virginia, has been described by Geo. W. Stose[1] of the U. S. Geological Survey. One is at Clinch Mountain 5 miles west of Saltville; nodular phosphate was found associated with quartz and limestone pebbles. This whole bed, however, is not more than 1 ft. in thickness. The other is at Walker creek at the east end of Brushy Mountain, 5 miles west of Marion; phosphate occurs both in nodular form and in layers associated with glauconite. The bed at this place has a thickness of 1 1/3 ft.

According to Stose the rock is probably of Devonian age and the geologic horizon at which it occurs can be traced for 20 miles in the Clinch Mountain region, and for about 2 miles in the Brushy Mountain locality. The best sample of rock examined was from the latter place and showed on analysis 54.97 per cent. bone phosphate of lime. Such material is not sufficiently rich in phosphate to be considered commercial rock, but it is hoped that further investigations in these fields will lead to the discovery of more extensive and richer deposits.

[1] *Bull.* 540 L., U. S. Geol. Survey, 1913.

A much more promising source of phosphate appears to be in the deposits of Nelsonite (described by Watson[1]) occurring in the foothills of the Blue Ridge near Roseland, Nelson County, and east of Roanoke, Roanoke County, Virginia.

There are several varieties of Nelsonite but the name was first given by Watson to a rock consisting of the two minerals ilmenite (iron titanate) and apatite or phosphate rock. This rock is of pre-cambrian age, and occurs in huge dikes, in places over 65 ft. in width and from several hundred to over 2000 ft. in length, as exposed on the surface. The unweathered rock is very hard but on exposure to weathering influences it can be readily broken up and a more or less clean separation made[2] of the two minerals.

The percentage of phosphate and ilmenite in Nelsonite varies considerably, some rock consisting mainly of the former mineral while in other samples ilmenite predominates. The separated apatite shows on analysis over 80 per cent. bone phosphate of lime.

At present the demand for ilmenite is very limited, and it will hardly pay to make a separation of the two minerals unless both can be marketed. It seems only a question of time, however, before the growing use of titanium and ferro-titanium will afford ilmenite a ready market and when this time comes the mining of Nelsonite should prove quite profitable.

No phosphate has yet been shipped from Virginia.

Phosphates in Foreign Countries

Africa

The phosphates of Northern Africa including those of Tunis, Algeria and Egypt are next in importance to those of the United States. Whereas the material on the whole is not as high grade as that from Florida and Tennessee its nearness to the European market has made it a serious competitor of the American product for the export trade.

The total output from the African deposits for 1913 was 2,328,777 tons as gainst 2,381,473 tons in 1912. Thus showing a decrease for the past year of 52,696 tons or 2.2 per cent.

Tunis.—Tunis has an annual output of phosphate second only to that of Florida. In 1913 the exportations amounted to 1,803,564 tons which is a slight decrease over those of 1912 when it was estimated that 1,923,000 tons were produced.

The main phosphate district is in the vicinity of Gafsa which is

[1] Geology of the Titanium and Apatite Deposits of Virginia, *Bull.* 111 A.
[2] Waggaman, W. H. A Possible Commercial Utilization of Nelsonite. *Jour. Ind. Eng. Chem.*, 5, No. 9, 1913.

connected with the port of Sfax by a railroad 150 miles long. The phosphate occurs in gigantic lenses of considerable thickness and ranges in grade from 58 to 68 per cent. bone phosphate of lime. The mining is done by open cuts.

The Societè des Phosphates de Gafsa which controls all the phosphate properties in the Gafsa region is the largest single producer of phosphate in the world and is constantly increasing its output. Its exports during the last 3 years were 1,121,759 tons in 1911, 1,312,378 tons in 1912 and 1,361,603 tons in 1913. The other companies in Tunis are the Societès des Phosphates Tunisiens, whose production for 1913 was 360,000 tons, and the Compagni des Phosphates du Dyrl.

The Tunisian Government is now completing a railroad from Sonatir to the port of Susa which will connect with a branch line of the Gafsa Co., thus affording the latter another shipping point. The Gafsa Co. has agreed to ship 250,000 tons annually over this road.

Algeria.—The phosphates of Algeria are of the same types as those of Tunis but have not been developed to the same extent. The total production in 1913 was 461,030 tons as against 388,515 tons produced in 1912. The most important company mining in Algeria is the Compagnie des Phosphates de Constantine. Its production in 1913 was 314,168 tons. Other companies operating in these fields are the Compagnie Centrale, the Compagnie Algerienne des Phosphates de Rocqueville and the Compagnie de M'Zaita.

A large factory for the manufacture of acid phosphate has been built at Oran and much of the Algerian rock will no doubt be used locally for the production of soluble phosphates.

The shipments of phosphate from Tunis and Algeria since 1895 are shown in Table VIII.

TABLE VIII.—SHIPMENTS OF PHOSPHATE ROCK FROM ALGERIA AND TUNIS.
(In metric tons.)

Year.	Algeria.	Tunis.	Year.	Algeria.	Tunis.
1895	104,603	.....	1904	344,969	457,133
1896	142,524	.....	1905	347,747	529,645
1897	227,870	.....	1906	302,262	747,303
1898	269,572	.....	1907	343,085	956,998
1899	286,681	65,209	1908	[362,890	1,270,020
1900	277,896	171,288	1909	351,491	1,224,822
1901	278,185	178,019	1910	319,069	1,286,262
1902	265,964	266,553	1911(a)	332,897	1,446,633
1903	301,112	360,621	1912(a)	388,515	1,923,000(e)
			1913	461,030	1,803,564

(a) Figures furnished by Charles Michel, Paris. (e) Estimate.

Egypt.—Phosphate deposits have been found in various parts of the Egyptian desert regions and in the valley of the Nile. The rock is of

cretaceous age and varies in grades from 30 to 68 per cent. bone phosphate of lime.

Mining is being conducted in two localities: in the Safaga District near the Red Sea coast and in the Sibaia District on both sides of the Nile.

Up to 1912 the latter region furnished practically all of the phosphate exported from Egypt but the Safaga deposits have now far surpassed those of Sibaia in annual output. The production of phosphate in Egypt for 1913 based on the material exported was 64,183 tons as against 69,958 tons produced in 1912. Over 90 per cent. of the rock exported was shipped to Japan as the passage through the Suez Canal is prohibitive.

The growing demand for phosphates in Japan promises an outlet for the stock of many embarrassed phosphate producers.

Islands of the Pacific and Indian Ocean

The highest grade deposits of amorphous phosphates yet discovered are those of the Pacific and Indian Oceans. Among the more important phosphate producing islands of the Pacific are Ocean Island (English) of the Guilbert Group, Tahiti and Makata (French) of the Society Group, and the Island of Naru (German) of the Marshall Group. Besides these Christmas Island in the Indian Ocean contains a large tonnage of high-grade rock. The statistics showing the total production from these islands in 1913 are not yet available but in 1912 the total explorations amounted to 600,000 tons. According to the *American Fertilizer*, Christmas Island produced in 1913, 150,005 tons.

The phosphates of these islands are derived from bird excrements which have been leached and their phosphoric acid fixed by the underlying coral rock; much of the material contains as high as 87 per cent. bone phosphate of lime. In cargo lots a grade of 82 per cent. is readily obtained.

The deposits of Ocean Island are controlled by English capitalists while French and German companies exploit the phosphate of Tahiti and Naru respectively.

The rock is mined by first removing the slight overburden and then digging out the phosphate rock with pick and shovel. Because of the lack of harbors the rock has to be loaded at sea; this is done by bringing the phosphate in cars to the jetties and there dumping it into baskets which are transported to the vessel in small boats.

The development of these deposits has brought about important changes in the phosphate industry. By mixing this very high-grade rock with the lower grade material from other sources a product is obtained closely approximating in richness the hard rock phosphate of Florida. It is therefore now possible to exploit lower grade deposits which could not be profitably worked before the advent of the ocean phosphates.

It is estimated that these Islands have a reserve supply of phosphate equal to 155,000,000 tons.

EUROPE

Russia.—Phosphorites occur over a very large area in Russia, but there are three main regions where the rock is of commercial value. These are as follows:

The Southern region, in the Governments of Podolia and Bessaribia where the deposits are close to the Austrian frontier; the Northern region where the deposits occur in Jurassic and Cretaceous rocks in the Governments of Viatka Vladimir, Kostrom, Ryazan, Sunbir and Yaroslavl; and the Central region of Cretaceous phosphates which are found in the Governments of Voronezh, Kaluzh, Kursz, Orel, Saratoff, Smolensk, Tamboff and Chernigoff.

The Northern and Southern regions have been examined geologically and the latter exploited, but little is known of the Central region except that phosphate exists in considerable quantities.

The phosphates of the Southern region are mined chiefly by underground workings. The average grade of the rock is said to be 75 per cent. bone phosphate lime. Much of the material is shipped to Poland and made into acid phosphate. The production of Russian phosphates for 1907 and 1911 is given in Table IX. Later statistics are not yet available. The average price delivered at the railway station was $9.30 per ton.

Fertilizers are imported to Russia in large quantities from Germany, Belgium and England.

TABLE IX.—PRODUCTION OF PHOSPHATE ROCK IN RUSSIA.
(Metric tons.)

Year.	Amount.	Value.
1907	11,290 tons	$104,997
1908	14,786 tons	137,510
1909	12,906 tons	120,226
1910	15,293 tons	142,225
1911	10,200 tons	94,860
Total	64,475 tons	$599,818

TABLE X.—IMPORTS OF FERTILIZERS TO RUSSIA.

	1910, Poods.	1911, Poods.	1912, Poods.
Mineral Phosphorites	1,520,000	1,770,000	.....
Other Nat. Fertilizers	67,000	353,000	.....
Unground Thomas Slag	125,000	11,000	.....
Crude Ground Bones	16,000	11,000	.....
Ground Thomas Slag	7,899,000	8,513,000	11,258,471
Superphosphates	7,359,000	9,425,000	11,491,153
Bones treated with Sulphuric Acid	20,000	21,000	.....
Roasted Bones	2,900	2,600	.....
Stassfurt Salts, German	3,087,000	4,155,000	.....
Chloride of Potassium	965,000	177,000	.....
Chile Saltpeter	1,744,000	1,936,000	.....

France and Belgium.—The phosphates of these two countries occur both in Tertiary and Cretaceous rocks as nodules in a matrix of clay or calcareous mud, and in the form of phosphatic chalk. Samples are found which contain as high as 70 per cent. bone phosphate of lime, the average grade of the rock, however, is not more than 50 to 55 per cent.

The main localities at which mining has been conducted are in the Departments of Somme, Pas de Calais, Meuse, Ardennes and La Marne in northern France, and at Mesvin and at Ciply near Mons in Belgium. At one time the phosphates of France and Belgium were of considerable economic importance to European agriculture but since the discovery and development of the higher grade deposits in other parts of the world mining has fallen off very greatly in these two countries.

As importers of raw materials and manufacturers of soluble phosphates and basic slag, however, France and Belgium are important countries in the phosphate industry.

In France there are about 200,000,000 francs invested in seventy-five factories which produce 1,600,000 tons of acid phosphate per annum. In addition to phosphate rock over 18,000 tons of guano from Peru and West Africa are annually imported to France.

The imports of phosphate rock for the past 4 years are given in Table XI.

TABLE XI.—IMPORTS OF PHOSPHATE TO FRANCE.
(Metric tons.)

From	1910.	1911.	1912.	1913.
Tunis	516,564	549,080	708,227	706,064
United States	(a)	(a)	(a)	120,724
All other countries	171,109	191,276	199,617	107,900
Total weight	687,673	740,356	903,489	934,688
Total value	$4,300,619	$4,594,285	$5,579,823	$5,767,025

(a) Not separately stated.

While Belgium produces only about 20,000 tons of phosphate annually 1,587 tons of which were shipped to the United States in 1913 and used for filler purposes, its annual exportations of Thomas Meal (a by-product of the steel industry) are over 600,000 tons. This material averages about 17 per cent. of phosphoric acid most of which is citric soluble. It is ground so that 75 per cent. passes a 100-mesh sieve and brings about $0.50 per unit of phosphoric acid. The domestic consumption of Thomas Meal is about 100,000 tons per annum. The total exports of fertilizer material as well as the exports of basic slag by countries are given in Tables XII and XIII.

TABLE XII.—FERTILIZER EXPORTS FROM BELGIUM

	1912 tons.	1913 tons.
Guano	26,345	24,839
Nitrate of Soda	114,777	123,313
Sulphate of Ammonium	17,413	14,999
Phosphate Rock	20,986	16,223
Thomas slag	616,181	629,058
Superphosphate	293,896	298,833
Oilcake	64,500	50,463
Bones, hoops and horns	18,623	18,509
Other fertilisers	50,745	50,073
Total	1,223,466	1,226,310

TABLE XIII.—EXPORTATION OF THOMAS SLAG MEAL FROM BELGIUM.
(Metric tons.)

Country.	1912.	1913.
Germany	325,283	312,446
Australia	2,611	3,247
Austria-Hungary	140	1,000
Spain	9,352	7,490
India	1,775	2,947
United States	14,717	18,596
France	10,679	13,119
Luxemburg	41,000	185
England	40,328	57,093
Hamburg	.....	1,056
Ireland	458	1,860
Italy	58,395	43,936
Norway	30,543	16,844
Holland	40,158	67,345
Portugal	8,076	6,256
Russia	43,535	38,554
Sweden	6,240	6,213
Other countries	23,849	31,867
Total (tons)	629,057	616,181

Germany.—Germany has no phosphate deposits of commercial value but imports a very large tonnage from the United States, Tunis, Algeria and Belgium. Its consumption in 1913 amounted to 803,054 metric tons as against 902,844 tons in 1912. Practically all of the rock is made into acid phosphate for domestic consumption.

TABLE XIV.—IMPORTS OF PHOSPHATE INTO GERMANY.
(Metric tons.)

Imported from	1911.	1912.	1913.
United States	378,770.4	342,646.3	421,212
Algeria	164,691.9	190,747.9	107,405
Tunis	62,267.1	115,206.1	108,707
Belgium	91,265.9	63,011.0	53,433
Christmas Islands	63,778.6	52,015.9	70,467
Australia	20,804.3	49,248.1	18,866
German Australasia	17,005.3	44,257.7	.....
France	15,681.9	40,686.4	19,529
Other Countries	18,994.2	5,024.8	4,129
Total	833,259.6	902,844.2	803,054
Total value	$9,915,794	$10,743,796	$8,664,953

Germany also produces an enormous quantity of Thomas slag both for the export trade and for domestic use the production of this material in 1912 was 2,110,159 tons. It sold c. i. f. Boston for $11.70 per long ton.

The importations of phosphate rock for the past 3 years are given in Table XIV.

England.—Phosphate in the form of coprolites has been found in various parts of the British Isles but not in sufficient quantities to prove of commercial importance.

This country however controls the rich deposits of phosphate on Ocean Island, and also has a large annual output of Thomas slag.

The imports and exports of phosphatic material for the first 11 months of 1912 and 1913 are given in Tables XV and XVI.

TABLE XV.—IMPORTATIONS OF PHOSPHATE MATERIALS TO ENGLAND.
(Metric tons.)

Material.	1912.	1913.
Basic Slag	41,883	43,403
Guano	11,723	17,285
Phosphate rock	462,414	486,989
Total	516,020	547,677

TABLE XVI.—EXPORTATIONS OF PHOSPHATIC MATERIALS FROM ENGLAND.
(Metric tons, 11 months.)

Material.	1912.	1913.
Superphosphate	82,514	61,416
Basic Slag	148,180	157,207
Total	230,694	218,623

Spain.—In Spain the mining of phosphate has practically ceased. In 1911, however, 3520 tons of low-grade phosphate rock were produced. The consumption of fertilizers in Spain based on the quantities imported is given in Table XVII.

TABLE XVII.—IMPORTS TO SPAIN.

	1912.	1913.
Imported nitrate of soda	45,701 tons	35,556 tons
Imported superphosphate and Thomas slag	160,547 tons	149,602 tons
Other fertilizers	91,855 tons	92,351 tons
Sulphate ammonia	15,000 tons	.....
Phosphate of lime equivalent in superphosphate made in Spain	317,129 tons	254,463 tons

South America

Peru.—The Peruvian guano deposits have been important sources of phosphoric acid and nitrogen since 1842. Many millions of tons have been shipped from these fields but with proper precautions for their conservation they can continue to furnish a fair annual tonnage almost indefinitely.

In 1890 the "Peruvian Corporation, Ltd" was granted the right to take guano from Peruvian territory up to the amount of 3,000,000 tons (an allowance which was afterward reduced to 2,000,000 tons) and over 50 per cent. of the guano from the Lobos Islands. Since that time up to April, 1913, the company has exported 1,134,198 tons.

It is reported, however, that the provisional government of Peru has issued a decree forbidding the exportation of guano from the Ballestas Islands on the grounds that the extraction of guano is interfering with the breeding of the birds, from which the deposits are derived.

There is now a large domestic demand for Peruvian guano. From 1896 to 1912 the consumption in Peru has been as follows:

1896–1900	18,384 tons
1901–1905	102,216 tons
1906–1910	177,212 tons
1911–1912	76,048 tons
Total	373,860 tons

The exportation of Peruvian guano to the various European countries for the past 2 years is given in Table XIV.

TABLE XIV.—EXPORTATIONS OF PERUVIAN GUANO.
(Metric tons.)

Exported to	1912.	1913.
Belgium	1,980	(a)
France	367	1,472
Germany	24,834	27,530
England	11,723(b)	17,285(b)
Total	38,904	46,287

(a) Not reported. (b) 11 months.

Other Countries

Japan.—Extensive investigations have been conducted by the Japanese in hopes of discovering phosphate in their country. Finally on Rasa Island at the extreme end of the Loochoo Islands deposits were discovered which according to the "Rasa Phosphate Mine Co." (a Japanese corporation) are nearly as rich as those of Ocean and Christmas

Islands.[1] The material averages about 77 per cent. bone phosphate of lime and 2 per cent. combined oxides of iron and alumina. It is estimated that the island contains about 2,800,000 long tons. These deposits however have not been developed to any great extent. Another locality where phosphate has been found in Japan is in the province of Eclugo. In 1911 there were 1374 tons produced. This is but a small percentage of the phosphate imported. Since the development of the phosphate deposits near the Red Sea, Egypt has been shipping 90 per cent. of its annual output to Japan, and a large tonnage is imported from Algeria, Tunis and the Islands of the Pacific.

China.—The American consul reports that phosphate occurs on the Pratas Islands 170 miles south of Hong Kong, China. A Chinese company under the name of "Tony Sahton and Pratas Islands Phosphate Syndicate" has obtained concessions from the Chinese Government to exploit these deposits. It is expected that work will be begun at an early date. The quantity of phosphate contained in the deposits of these islands is estimated at 960,000 tons.

West Indies.—Work was resumed at the phosphate mines on the Island of Curacao (Dutch West Indies) in Oct., 1913, after a suspension of 20 years. One thousand eight hundred fifty tons were taken out during the year by an English Company. The phosphate from this island is exceptionally high grade containing 87 per cent. bone phosphate of lime and less than 1 per cent. of the combined oxides of iron and aluminum.

Technology

Many attempts have been made to render phosphate rock water soluble or agriculturally available by means other than its treatment with sulphuric acid. In the United States alone over 200 patents have been issued on this subject but few of them have proved commercially successful. Brief descriptions of some of the more recent and important of these processes are given below.

Wilson and Haff Processes.—These two men have taken out several patents[2] for the production of phosphoric acid and soluble phosphates. The process, however, which has been attracting great attention is one for the manufacture of pure phosphoric acid without the use of any other acid. It consists in heating a mixture of phosphate rock and sand or siliceous material to a temperature of 1600° C, in an electric furnace and collecting the phosphoric acid thus volatilized. By using a potash

[1] *Amer. Fertilizer*, Oct. 7, 1911.
[2] U. S. Patents Nos. 1018186, 1040081, 1062869.

feldspar instead of sand it is claimed both potash and phosphoric acid are driven off.

F. S. Washburn[1] and Georgio Levi[2] have also taken out patents which are very similar to Wilson and Haff's, except that Washburn states that the presence of carbon in the mixture is essential for the complete volatilization of the phosphoric acid.

Theoretically these processes are the logical method of obtaining phosphoric acid for subsequent fertilizer manufacture, but they require very cheap electric power for their commercial success.

The proposed development of an enormous amount of hydroelectric power on the Saguenay River from Lake St. John to tidewater in the province of Quebec may furnish the cheap power required.

Collett's Process.—The process of Emil Collett[3] consists in treating phosphate rock with dilute nitric acid, then adding ammonium sulphate to this solution. Ammonium phosphate is thus formed and the lime precipitated as gypsum which can be separated either by decantation or by filtration.

Utilization of Acid and Basic Slag.—A bulletin[4] of the U. S. Dept. of Agriculture describes a method of obtaining both phosphoric acid and potash in a citric soluble form by the addition of phosphate rock and feldspar to the slags produced in the steel industry. It is thus possible to utilize the high temperature of these slags for the production of a salable substance. Pot tests with the fertilizer material gave favorable results.

Bibliography

Arlt, H.—Die Mineralschätze Tunisiens." *Glückauf*, July 19, 1913, p. 1125 July 26, 1913, p. 1169.

Bell, John.—Phosphate Deposits of Egypt. *Min. Jour.*, Aug. 9, 1913, p. 755.

Benker and Millberg.—L'Excavation Micanique des Fosses a Superphosphate et Notamment au Moyen de L'Appareil du Systeme Wenk. *Le Phosphate*, Aug. 4, 1913, p. 733.

Brogdon, J. S.—The Manufacture of Acid Phosphate. *Am. Fertilizer*, Sept. 6, 1913, p. 25.

Ciselet, Joseph, and Noblet, Paul.—Procedè de Traitement des Phosphates Naturels par l'Obtention d'Engrais Pouvant Etre Employes en Agriculture. *Le Phosphate*, Dec. 30, 1912, p. 1143.

Ebaugh, W. C.—Phosphates, Potash and Nitrates. *S. L. Min. Rev.*, May 15, 1913, p. 22.

Elschner, C.—The Island of Nauru." *Am. Fertilizer*, Dec. 13, 1913, p. 23.

Jones, C. C.—The Discovery and Opening of a New Phosphate Field in the United States. *Bull. Am. Inst. Min. Engrs.*, 82, Oct., 1913, p. 2411.

[1] U. S. Patent 1044957 (1912).
[2] U. S. Patent 984769 (1911).
[3] U. S. Patent 1058145 (1913).
[4] *Bull.* 95, Bureau of Soils, U. S. Dept. Agriculture, 1913.

MAYNARD, T. P.—White Rock Phosphates of Decatur County, Tennessee. Resources of Tenn., July, 1913, p. 161.

PARDEE, J. T.—Some Further Discoveries of Rock Phosphate in Montana. *Bull.* 530-*H*, U. S. Geol. Surv.; *Am. Fertilizer*, Feb. 22, 1913, p. 42.

PHALEN, W C.—Phosphate Industry in Florida in 1912. *Min. Eng. World*, Aug. 16, 1913; p. 301.

PHALEN, W. C.—The Production of Phosphate Rock in 1912. Min. Res. of U. S., 1912; *Am. Fertilizer*, Aug. 23, 1913, p. 41.

POIZAT, C. DU.—A Propos des Phosphates d'Egypte. *Echo des Mines*, Oct. 9, 1913, p. 1027.

SCHULTZ, A. R., AND RICHARDS, R. W.—Existing Phosphate Land Reserves in Southeastern Idaho. *Bull.* 530, U. S. Geol. Surv.; *Min. Sci.*, Feb. 27, 1913, p. 136; *Am. Fertilizer*, Feb. 22, 1913, p. 37.

SELLARDS, E. H.—Origin of the Hard Rock, Phosphate Deposits of Florida. (Fifth Annual Report, Fla. State Geol. Surv.

WAGGAMAN, WM. H.—A Report on the Phosphate Fields of South Carolina. *Bull.* No. 18, Bureau of Soils, U. S. Dept. of Agriculture.

WAGGAMAN, WM. H.—Die Phosphat Ablagerungen der Vereinigten Staaten. *Kunstdünger-Industrie*, Dec. 7, 1912, p. 424.

WAGGAMAN, W. H.—The Utilization of Acid and Basic Slags in the Manufacture of Fertilizers. *Bull.* 95, Bureau of Soils, U. S. Dept. of Agriculture.

————. Der Guano und sein Handel. *Zentr. Kunstdünger-Industrie*, Feb. 7, 1913, p. 51; Feb. 21, 1913, p. 68.

————. Makatea; les Phosphates de L'Oceanie. *Le Phosphate*, March 3, 1913, p. 205.

————. Phosphate Deposits and the Law. *Min. Sci. Pr.* May 31, 1913, p. 807.

————. Phosphate Industry of Algiers. *Am. Fertilizer*, June 28, 1913, p. 44.

————. *The American Fertilizer Handbook*, 1913. Philadelphia, 1913.

PLATINUM AND ALLIED METALS

By F. Lynwood Garrison

The production of platinum in the United States is quite small, and when compared with the consumption of the country is practically negligible, usually amounting to about 1000 ounces a year. This is obtained mostly as a by-product in placer gold mining in northern California and Oregon. A small proportion of the yield comes from the New Rambler Copper Mines in Albany Country, Wyoming. Some of the platinum is separated from the gold by the miner and sold as crude metal, but the majority of it is separated from the gold at the Mint, or by the refiner of the gold.

The United States ranks low as a producer, but as a refiner of platinum, it is of considerable importance. Most of the crude metal is of Russian origin, but very little if any is received directly from Russia ,the shipments being made through firms in England, Germany, and France. After Russia, the next important contributor to the United States supply is Colombia.

STATISTICS OF PLATINUM IN THE UNITED STATES.

Year.	Production. (a)		Imports.			Total.
			Unmanufactured.		Manufactured.	
	Troy Oz.	*Value.*	*Troy. Oz.*	*Value.*	*Value.*	*Value.*
1897	150	$ 900	83,080	$ 960,299	$ 43,921	$1,005,120
1898	225	3,375	101,018	1,178,142	52,283	1,233,800
1899	300	1,800	187,778	1,462,157	55,753	1,539,710
1900	400	2,500	118,919	1,728,777	36,714	1,767,991
1901	1,408	27,526	85,438	1,673,713	24,482	1,725,721
1902	94	1,814	105,450	1,950,362	37,618	1,989,794
1903	110	2,080	114,521	1,921,772	135,889	2,059,741
1904	200	4,160	103,802	1,812,242	105,636	1,920,478
1905	318	5,320	104,196	1,985,107	188,156	2,176,263
1906	1,439	45,189	137,556	3,601,021	187,639	3,797,460
1907	357	10,589	74,208	2,509,926	175,651	2,696,166
1908	750	14,350	50,768	1,096,615	134,119	1,244,984
1909	638	15,950	118,851	2,557,574	410,997	2,984,521
1910	773	25,277	120,478	3,320,699	333,965	3,679,941
1911	940	40,890	122,390	4,722,752	135,842	4,899,484
1912	1,005	45,778	104,683	4,334,488	159,995	4,540,261
1913	.....	.....	117,947	4,938,706	105,553	.....

(a) Statistics of the U. S. Geol. Surv.

Market.[1]—The platinum market during 1913 was inclined toward lower prices, owing largely to a less demand by the electric and jewelry trades. It is said that the manufacturing jewelers find the metal too expensive for general use in jewelry and rumors within the past few months intimate that the electrical manufacturers have found a substitute which answers their purpose very well. Experiments in the latter direction have been progressing for some years and they seem to have been crowned with more or less success. The automobile industry is still using platinum and iridio-platinum sparking points, which creates a demand that a few years ago was not in evidence. This is a considerable consumption. Every magneto has a pair of platinum points, or buttons, which completly wear away in two to four years of use.

So far as the dental trade is concerned, the introduction of base-metal-pin teeth a few years ago has had a marked tendency to cut the demand materially, and the present high cost of the metal has caused much activity in the experimental line, but with not very marked success. Some coated wire is being used, and if it proves successful, will greatly reduce the use of platinum in the dental trade.

At the beginning of 1913 quotations for the metal in good-sized lots were $44.25@45 per ounce, New York. About June 1 there was a decline of about $1 per ounce, which has ruled since. This refers to the conditions of the big trade, in which purchases of 500- to 1000-oz. lots are common and 100 oz. is only an ordinary transaction. In the retail trade, 5-oz. lots, etc., there are more fluctuations in price.

For lots of ordinary size—100 oz. or under—the ruling price for three-quarters of the year was $45@46 per ounce. Late in the year prices declined $1 or more and about $43.50 was the ruling quotation. Scrap seems now to be weaker than new metal, and a number of choice lots have been, and are still offered at $41@42 per ounce. This is mostly from the chemical manufacturing establishments, particularly the producers of acids, and consists of old stills and apparatus of various sorts.

Palladium is ruling about the same as platinum, although it should not do so, being of less value. On account of the light demand, some lots have sold as low as $40, but the prevailing quotations are closed to platinum rates.

Iridium is firm at $74@75 per ounce in lots of 100 oz., with a decided tendency to decline on account of little demand, it being used only in small quantities as an alloy. For several months the supply was short and for a time prices went up to $81 and even $85 per ounce. This caused an advance in hard metal—platinum-iridium alloy—from $3 to $6 per ounce over the price of refined platinum being charged.

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK.
(In dollars per troy ounce.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
January.. ...	20.50	38.00	25.50	24.10	29.00	39.06	46.00	45.50
February. ...	25.00	38.00	25.50	24.00	28.75	39.31	45.63	45.50
March.....	25.00	37.00	25.50	23.75	29.13	41.00	45.50	45.50
April..... ...	25.00	32.50	23.50	23.50	29.25	41.35	45.50	45.50
May.....	25.00	29.50	22.50	23.25	29.55	42.81	45.50	45.50
June.....	25.40	26.20	23.50	22.75	31.38	42.88	45.50	45.50
July.....	26.00	26.75	20.00	22.43	33.00	42.95	45.50	45.50
August.....	26.00	28.13	18.75	22.65	33.00	44.38	45.50	44.90
September....	32.10	28.70	20.00	25.31	33.63	45.31	45.50	43.96
October.....	33.00	27.13	21.50	27.75	37.50	46.25	45.50	44.00
November....	35.50	26.31	24.00	29.50	39.44	46.13	45.50	43.70
December.....	38.00	26.00	24.00	29.50	38.75	46.00	45.50	43.45
Year.....	28.04	28.18	22.85	24 87	32.70	43.12	45.55	44.88

COMPARATIVE AVERAGE PRICES OF PLATINUM IN NEW YORK AND RUSSIA.
(In dollars per ounce troy.)

	New York Refined Platinum.	Russia 83% Crude Metal Platinum. St. Petersburg.	Ekaterinburg.
Jannary	45.50	36.93	36.45
February	45.50	36.95	36.46
March	45.50	36.95	36.47
April	45.50	36.98	36.47
May	45.50	37.01	36.50
June	45.50	37.01	36.66
July	45.50	36.97	36.66
August	44.90	36.50	36.30
September	43.96	35.72	35.67
October	44.00	35.72	35.67
November	43.70	35.72	35.74
December	43.45	36.02	35.90
Year	$44.88	$36.54	$36.25
Average for 1912	45.55	37.08	37.05
Average for 1911	43.12	35.21	35.09
Average for 1910	32.70	26.96	26.37

Foreign Countries

Australia.—The exports of Australia in 1912 amounted to 652 oz. of crude metal, valued at £4131, as compared with 470 oz. valued at £2999 in 1911.

The discovery of traces of platinum in the northeastern portion of South Australia has been reported by the Government Geologist.

Tasmania reports for 1912 the production of 778.77 oz. of osmiridium, valued at £5742, and for 1913, an increase to 1261.65 oz., valued at £12,016. New South Wales reports a 1913 production of 442 oz. of platinum.

Borneo.—In outward appearance the platinum ores of the island of Borneo differ considerably from those of the Urals. While the latter are found in the form of grains, the Borneo platinum consists of much worn small flakes or scales, and is very seldom crystalline. Their blend is metallic and the color is white. Borneo platinum, on the Peninsula

Tana-Lavet, is always accompanied by gold and osmiridium, while the former in most cases greatly predominates in point of quantity. Frequently there are found flakes, one side of which is of the color of gold and the other platinum. This is a twin occurrence of gold and platinum grains.

Platinum on the island of Borneo is found on the land of the former concession of Goenoeng Lawak, on the course of the River Riam-Kiwa and Riam-Kanan Bankoe krang in alluvial and diluvial accumulations, Batti-Batti and Pleirie, and also in some placers ("Parit"), situated east of the great road from Martapoera to Pbiari, at the end of the Meratoes Mountains, which terminate the southern extremity of the Tanabi Lavet Peninsula. Analysis of the samples of Borneo platinum ores show the chemical variations in them, and at the same time the major portion of the metals contained in them: Platinum from 58 to 75 per cent.; osmiridium from 0.18 to 10.07 per cent.

Canada.—It is known that the Sudbury ores carry not only nickel and copper, but also a proportion of the precious and rarer metals, including gold, silver, platinum and palladium. Cobalt is likewise a constituent, but since the opening up of so prolific a source of supply of this metal in the silver mines of Cobalt, there is no inducement to recover the small proportion of cobalt contained in the Subdury pyrrhotites. The rare metal rhodium, which is almost invariably contained in crude platinum to the extent of about 2 per cent., and which is at present worth $5 per gram, or $155 per ounce, is also present in these ores, and a little is said to be produced in the United States, partly from platinum sand, and partly from Canadian and other copper bullion. Another rare metal, ruthenium, an accompaniment of the mineral iridosmine, is also said to occur in the copper ores of Sudbury.

The platinum is present in the unaltered ores of Sudbury as sperrylite, or arsenide of platinum, associated with the chalcopyrite. The Canadian reports do not show the production for the year. Exports amounted to 158 oz.

Colombia.—Next in importance to the Urals, as a source of platinum, is the Choco district in the Republic of Colombia, S. A., which in 1912 supplied 11,750 oz. The locality thus loosely defined is an irregular, partly explored area at the head waters of the Atrato and San Juan rivers, between lat. 1° 30′–6° N. The town of Quibdo is the commercial but not the geographical center of this district. Here the alluvial platinum and gold deposits are found in the beds of small streams which rise in the Western Cordillera and flow westward into the Atrato and San Juan rivers. Relatively little platinum occurs in the streams that flow east from the eastern side of these mountains; hence it is probable the rocks from which

this metal is derived are chiefly on the western slope. Ospina[1] states that specks of platinum have been found in the amphibolitic rocks of the Condoto section and while the evidence he adduces to support this statement is not altogether convincing, on general principles, it seems highly probable. Kimball[2] states that he was shown in the Choco district a specimen of a basic, igneous rock, probably a peridotite, carrying native platinum in small flaky particles. We know from observation in other parts of the world that the habitat, so to speak, of platinum is in basic rocks, more particularly peridotite, serpentine and pyroxenites. Such rocks are probably abundant on the Western slopes of the mountains aforesaid, as some platinum is nearly always found in the streams flowing down from them. But it does not follow from this that wherever you have these basic rocks one is certain to find platinum.

The Condoto is a small stream which flows into the headwaters of the San Juan river near the town of San Pablo. This is the heart of the platinum producing section of the Choco district; the Condoto and its much larger neighbor, the Tamana, appear to drain a rugged section of mountains and hills composed largely of basic rocks. According to Ospina[3] the gold washed from the Condoto carries as much as 40 per cent. or more of its weight in platinum, which is always combined to a greater or less extent with iridium, osmium, palladium and rhodium.

Colombia seems to have exported platinum at a comparatively early date; a time when little was known about the properties of the metal or proper methods of working it. Consequently its value then was small as compared to gold, and the natives threw it away for the traders considered it detrimental to the gold they brought to sell. This fact in later times has produced a rather amusing condition at Quibdo district. Thus the ground upon which the old trading stores were located, has become valuable in consequence of the platinum thrown out of the window. In some cases it is said the soil surrounding such sites has yielded large returns of platinum when carefully washed.

According to the French traveller Mollien, as early as 1810, as much as 6000 lb. of platinum was exported from the Choco district, but he does not say whether this was the production for 1 year or the cumulative production of several years. He states it had a value then of 6 piastres per Spanish pound (14 3/4 troy oz.) which is about equal to $5.00 or $6.00 per lb. in our money. In 1823 when this exportation was prohibited, prices dropped to from 3 to 4 piastres per pound.[4]

Platinum mining in Colombia is therefore an old industry, although as

[1] Reseña sobre la Geologia de Colombia, y especialmente del antiguo Departamento de Antiognia. Mendellin, 1911, page 58.
[2] *Bull.* 65, *Min. Met. Soc.*, page 276.
[3] *Loc. cit.*, p. 56.
[4] Travels in the Republic of Colombia in the year 1822–1823, pp. 307, 457.

compared with Russia, its production has never been very large and it is perhaps no greater to-day than at any previous period.

Modern methods must needs be introduced and the trade pass into strong and progressive hands before Colombia can do justice to itself in regard to the production of platinum. At present this trade seems to be almost entirely in the hands of Syrians (locally termed Turks) who, as storekeepers and merchants, control the output and as a consequence, in some cases, have grown quite rich. The climate of the Choco district has justly a bad reputation. On the other hand it is, comparatively speaking, easy of access by the Atrato river from Cartagena, or by rail and canoe from the port of Buena Ventura on the Pacific Ocean. But Colombia is no poor white man's country; its unhealthy malarial valleys may be conquered only by rich and powerful companies who can organize the natives and work them in conjunction with modern mechanical apparatus. Doubtless the production of this large region may thus be greatly increased in the near future, despite the unhealthy climate, and other difficulties incident to large operations in the tropics, which must be experienced to be fully appreciated.

UNITED STATES IMPORTS OF PLATINUM FROM COLOMBIA.
(In troy ounces.)

Year. (a)	Quantity.	Value.
1907	5,496	$100,206
1908	1,092	25,576
1909	2,392	36,440
1910	1,600	31,383
1911	5,503	147,820
1912	6,627	219,128

(a) Fiscal year ending June 30.

Statistics compiled by the Colombian government show that there was exported in 1912, platinum to the valuc of $495,188.20.

Statements from irresponsible sources regarding platinum deposits and platinum mining in Colombia should be accepted with reserve. The platinum industry of Colombia has never been in strong, trustworthy hands, but it is only a question of time when it will be. Modern methods will then displace the present slipshod system dependent upon the whims of the poor natives of this unsalubrious district and the equally irresponsible but much more cunning and unscrupulous traders.

Germany.—The reported discovery of platinum at Wenden in Westphalia, in payable quantities, is of more than passing interest. The published statements regarding these deposits appear to be reliable and will probably soon be either discredited or confirmed by official reports. Of one thing we may be sure, that is, that the German Government will

investigate this matter with its characteristic thoroughness and scientific skill.

It seems that during certain prospecting operations for other minerals, drill cuttings were obtained in which platinum was found. It is stated that in the borings from an area of 500 acres, platinum was obtained in nine different drill holes. A writer in a recent issue of the *Mining Journal* states that deposit so far prospected at Wenden contain about 25 to 37 grm. (31 grm. = 1 oz.) of platinum per ton, and some gold and silver.

There are a few other places besides the one at Wendén known already and here, too, the platinum mostly takes first place. Some interesting analyses follow:

	Pt.	Au.	Ag.
(1)	7	trace	820 grm. per ton.
(2)	10	10	72
(3)	34	2	— (besides 12 grm. Iridium and Rhodium.)

The metals were first discovered in 1864 by C. Schreiber, of Krombach, near Siegen, who died some weeks ago. He devoted all his life to this matter in prospecting and making several thousand analyses. Another published statement avers that over 100 analyses of borings have been made and all showed the presence of metal in amounts sufficient for profitable extraction, the quantity varying from 0.9 to 1.9 troy ounces per cubic yard, which is very rich compared with the Russian deposits.

It seems that the Westphalian platinum occurs in the form of an alloy, and in the customary course of analysis entered into solution in the form of a nitrate. A chemist decided to test the solution of nitrates obtained in the normal course of an analysis for the possible presence of platinum, and this led to the unexpected discovery. There is every possibility that not only in Germany, but in all other countries rock analyses will promptly be submitted to revision, and the greatest care be taken to ascertain whether platinum is present. Deposits containing much less platinum than occurs at Wenden can still be worked most advantageously."

Russian Platinum in 1913. (By. J. P. Hutchins.)—More than 90 per cent. of the total world's production of platinum comes from the Ural Mountain region, where it is won by dredging, drifting and open-cutting. The constant high price of about $36 to $40 per ounce at Ekaterinburg, the market place for 83 per cent. crude platinum, was a constant stimulant to new exploration and exploitation; but no new extensive placers were discovered. All of the platinum comes from placers and more than 50 per cent. of it is recovered by dredging with generally very inferior dredges of poor design and construction, and with consequent low capacity and high working cost. As an example, there is one company

that produces about $1,600,000 worth of platinum yearly, with light dredges, which each work about 1200 cu. yd. per day and it takes about 39 men to run each dredge. About 25 per cent. of the platinum is probably lost through incomplete disintegration of gravel containing much clay. A properly designed dredge of American type, with the same sized buckets, will dredge twice as much, save over 90 per cent. of the platinum, at a cost less than one-half, and needs about 9 instead of 39 men to run it.

The following official figures show the productions of platinum for the last 18 years in Troy ounces:

PRODUCTION OF PLATINUM IN RUSSIA.

Year.	Official.	Actual.	Year.	Official.	Actual.	Year.	Official.	Actual. (a)
	oz.	oz.		oz.	oz.		oz.	oz.
1896.....	158,326	200,000	1902.....	197,024	380,806	1908.....	156,792	250,000
1897.....	179,879	395,200	1903.....	192,976	226,000	1909.....	164,513	275,000
1898.....	193,213	203,100	1904.....	161,950	290,120	1910.....	176,334	300,000
1899.....	191,464	380,900	1905.....	167,950	200,450	1911.....	187,008	280,000
1900.....	163,060	212,500	1906.....	185,546	210,318	1912.....	177,596	300,000
1901.....	203,257	315,200	1907.....	172,064	310,000	1913.....	170,000	275,000

PRODUCTION OF PLATINUM IN THE URALS.
(In troy ounces.)

District.	1908.	1909.	1910.	1911.	1912.
South Verchotur.....	97,747	100,986	111,070	121,317	118,281
North Verchotur.....	13,032	14,727	11,858	11,367	13,061
Perm.....	36,735	39,867	46,071	46,882	38,706
Tcherdinsk.....	7,452	7,161	6,361	(a)6,400	6,166
South Ekaterinburg.....	1,826	1,772	974	(b)1,042	(c)1,382
Total.....	156,792	164,513	176,334	187,008	177,596

(a) Estimated. (b) Includes 2 oz. from North Ekaterinburg.
(c) 5 oz. from North Ekaterinburg.

The sale price of platinum is controlled by a French Company, which markets about 75 per cent. of the total amount of platinum produced and prevents the violent fluctuations of former years. For instance, in 1903 the price was one-thirteenth what it was in 1913. This was largely a matter of over-production, however. The present demand for platinum is strong and increasing. The prices of platinum for several years appear in the following:

Year		Year	
1903.....	$ 2.60 to 3.00 per oz.	1911.....	$37.50 per oz.
1906.....	23.00 to 24.00	1912.....	37.50 to 38.25
1908.....	$14.50 to 24.50.	1913.....	$36.25 to 39.50
1910.....	22.50		

Always associated with platinum are iridium, osmiridium, palladium and other metals of the platinum family. No extra allowance in selling

is made for these metals, although some of them are far more valuable than platinum.

About one-third of the platinum is used in dentistry, one-third in jewelry and one-third in the manufacture of chemical apparatus. An alloy consisting of 75 per cent. platinum and 25 per cent. iridium makes the strongest precious metal setting for jewels and, being so strong, permits settings of extreme fineness and of design with very thin filaments, that are more beautiful than it is possible to fabricate when using any alloy of gold.

The project to make the control of platinum mining, refining and selling, a Government monopoly, is expiring like many of the other fantastic proposals of a hyper-paternal Government, which more often obstructs than assists.

Geology

As has been previously intimated, the platinum of commerce comes almost entirely from alluvial or detrital deposits, the sands and gravels of small streams and rivers resulting from the wearing down or erosion of the rocks of the districts through which they flow. Such platinum is nearly always accompanied by gold, derived also from the rocks in a similar manner. The source of the gold is of course the veins in these rocks, for they are broken down and eroded by the same forces that disintegrate and waste away the rocks. For many years the origin of the platinum was a mystery; diligent search failed to locate it in the veins, although it was observed that platinum alluvials appear to favor certain localities in which basic olivine rocks were common.

Further study and refined chemical analyses finally located metallic or native platinum in a group of magnesian rocks known as peridotites and the serpentine arising from their alteration. It does not necessarily follow that platinum is commonly found in such basic rocks; on the contrary it is exceedingly rare in them, but whenever it does occur in place, it is usually with rocks of this character. Some exceptions may be noted.

Thus platinum has also been observed by Hundeshagen in Wollastonite on the Island of Sumatra and is not there found in the associated magnesian rocks.[1] Similar conditions obtain in Borneo; in fact, Hundeshagen concludes that in the Indian Archipelago the occurrence of platinum is universal and that when found is not derived from serpentine.

But in its usual associations platinum is found with basic igenous rocks that are rich in the mineral olivine or chrysolite, these rocks are likewise

[1] *Trans. Inst. M. & M.*, 18, 550.

the home of chromite, the commonest consort of platinum. These peridotites change rapidly under metamorphosing influences to serpentine, and it is therefore not suprising to find that platinum is often traceable to this mother rock.[1] Platinum has also been detected in the pyroxenites of the Tulameen region, British Columbia. It has likewise been reported elsewhere from syenites and gabbros. Kemp cites a number of cases in which it has been found associated with both gold and copper ores as well as the nickel-copper ores of Sudbury, Ont.[2]

Platinum has been found at many points in the south island of New Zealand but never in sufficient quantity to be of any economic value excepting where saved with gold. A number of platiniferous quartz veins were discovered there a few years ago by J. M. Bell near the Teremakau River in the district of Westland in the South Islands, in close proximity to sheets of altered magnesian eruptives (dunite apparently). The platinum was associated with silver in the ratio of about seven parts silver to one of platinum.[3] Various occurrences of this metal might be cited indefinitely.

It is evident from this brief sketch that the geological and mineralogical conditions surrounding the original sources of platinum are beginning to be understood, but space does not here admit a further technical discussion of the subject, although it is one of growing economic importance and holds out some faint hope that we may yet find an original supply in the rocks, their veins and associated ores. The Sudbury district in Ontario already thus yields a small measure of platinum from its nickeliferous pyrrhotite and chalcopyrite ores. Here it occurs as an arsenide of platinum ($PtAs_2$) known as sperrylite.

All things considered, it seems unlikely that any considerable increase over the present rates of production of platinum can be expected in the near future unless some new and large deposits are found. The improved methods of mining that are slowly being introduced in the Urals will probably not much more than compensate for the natural decrease due to exhaustion. As to Colombia, predictions are even more hazardous, for conditions are quite different from those in Russia. The normal production of Colombia has always been erratic and that is the only certainty about it. The installation of dredges into the Choco district is a very serious and difficult matter and they are the only means by which a large and steady production (along with gold) can be maintained. However, all things considered it seems probable there will be a considerable improvement in the platinum production of Colombia, but just how soon it may be appreciable will be difficult to predict, although the writer is

[1] Kemp, MINERAL INDUSTRY, X, p. 541.
[2] *Ibid*, pp. 542, 543.
[3] *Econ. Geol.*, 1, 749 (1905–1906).

in a position to be well informed upon the subject. It is therefore evident if the supply of platinum is to meet the ever increasing demand, new districts must be sought in other parts of the world. The list of localities where platinum has been found is a long one and need not be detailed.[1] With but few exceptions these deposits or occurrences appear to be unimportant in a commercial sense however interesting they may be to the geologist. They show in the main a marked similarity of geologic environment, and give us at least a cue as to where to look for new deposits. With vast areas in Siberia, British North America and Alaska, not to mention South America, unprospected, it would indeed be rash to conclude that no platinum producing districts comparable to those of the Urals may not at some future time be discovered. But pending that event, we must look to improved methods and strong hands to stimulate the production in the Urals and in Colombia. Substitutes for platinum will doubtless continue to be offered and the field here for the inventor is wide and should be lucrative.

The present high price of platinum will without question, stimulate prospecting, and our present knowledge of its geologic and lithologic surroundings should tend to make this search more easy and successful. We need therefore not be without hope for an increased supply and a consequent lower price, but at the same time hopes are known to be delusive. For the immediate future, it seems more than likely little or no increase may be expected, or that the demand will materially lessen.

Bibliography

Anon.—A Small 'Hellberger' Electric Furnace for Melting Platinum. *Brass World*, **8**, 273.

(Anon.—Electrodeposition of Platinum. *Brass World*, **9**, 55, 6.

Bailey, F.—Platinum in British Columbia. *Min. Jour.*, Mar. 1, 1913.

Day, D. T.—Production of Platinum in 1912. *Min. Res. of U. S.*, 1912.

Duparic, L.—Origin of the Platinum contained in the Alluvials of Certain Lateral Tributaries of the Koswa, North Ural. *Comp. rend.*, **156**, 411–13.

Eilers, A.—Occurrence of Some of the Rarer Metals in Blister Copper." *Trans. A. I. M. E.*; *Min. Eng. World*, Nov. 15, 1913.

Gaus, C.—Recovering Full Value from Platinum Scrap and Filings. *Metal Ind.*, **11**, 211–12.

Gutbier, A.—Zur Kenntnis des Osminum. *Chem. Ztg.*, July 17, 1913.

Hautpick, E. de.—Commercial Aspects of Iridium Production. *Min. Sci.*, Mar. 6, 1913.

Hautpick, E. de.—Gold and Platinum in Mongolia. *Min. Jour.*, Feb. 1, 1913.

Hautpick, E. de.—Occurrence of Platinum in the Urals. *Min. Jour.*, Sept. 20, 1913.

Hirshberg, L. K.—Mining Platinum. *Mex. Min. Jour.*, June, 1913.

[1] See *Bull.* 491, *U. S. Geol. Surv.*, pp. 668–672.

HUTCHINS, J. P.—Dredging by Hand in Siberia. *Min. Sci. Pr.*, Nov. 22, 1913.

KELLER, H. F.—Methods Employed in the Extraction and Purificationof Paltinum. (*Jour. Frank. Inst.*; *Min. Eng. World*, Apr. 26, 1913.

Kimpball, E. B.—Primitive Methods of Working the Platinum Areas of Colombia. *Min. Eng. World*, Jan. 17, 1914.

SIEG, L. P.—Note on the Elastic Properties of Platinum-Iridium Wires. *Phys. Rev.*, 35, 347–58.

STOVALL, D. H.—Method of Saving Placer Platinum on Burlap Tables. (*Min. Eng. World*, June 14, 1913.

SCHATTEBECK, C. C.—Condition of the Platinum Market. *Min. Sci.*, May, 1913.

SONNTAG, B.—Kolumbia als Platinproductionsland. *Zeit Ver. Bohring. u. Bohrtech.*, Mar. 15, 1913.

WEIGHTMAN, .H. E.—Spot Welding (Electric) of Platinum Points. *Elec Rev West. Elec.*, 63, 686.

————. Russian Platinum. *Min. Sci. Pr.*, Oct. 11, 1913.

POTASSIUM SALTS

While no features in the potash trade changed the relations with the foreign source, the efforts made to find new sources in the United States has continued energetically. The reconciliation between the American buyers and the German producers has proved to be permanent. The following table shows the imports of potassium salts of various kinds for consumption for fiscal years:

IMPORTS OF POTASSIUM SALTS. (a)
(Tons of 2000 lb.)

	1909.		1910.		1911.		1912.		1913.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bicarbonate	171	$ 16,915	167	$ 16,633	163	16,428	138	$ 13,155	156	$ 14,295
Carbonate (crude)	4,814	324,540	4,204	263,643	5,340	327,400	3,299	207,417	5,032	295,066
Carbonate (refined)	5,505	379,392	4,518	303,917	5,572	395,728	5,313	383,958	7,018	412,587
Chloride	148,669	4,758,907	195,927	5,640,541	214,283	6,449,575	242,033	7,235,728	223,837	6,737,757
Chlorate	10	1,655	207	26,608	12	2,096	21	3,444	618	66,609
Chromate	86	12,330	439	43,037	11	1,699	22	2,273	14	2,601
Cyanide	1,376	386,354	1,211	328,146	1,163	326,973	1,048	312,777	475	137,535
Hydrate (crude)	3,521	294,409	4,392	358,855	3,713	309,965	4,211	330,684	4,497	348,500
Hydrate (refined)	64	9,289	72	11,095	41	9,254	39	8,096	56	11,719
Kainit	344,526	1,974,165	484,155	2,313,150	656,842	2,637,106	479,817	2,400,590	466,184	2,149,689
Nitrate (crude)	8,735	512,473	12,573	675,765	4,645	282,835	3,086	213,258	5,495	288,995
Nitrate (refined)	208	14,421	1,306	115,457	426	38,384	221	23,896	197	22,142
Prussiate (red)	39	13,522	33	12,460	27	10,230	35	11,264	33	11,302
Prussiate (yellow)	877	178,744	1,165	229,907	889	180,584	1,036	203,295	1,406	309,302
Sulphate	30,508	1,148,607	42,485	1,399,915	53,135	1,952,371	50,551	1,853,236	48,023	1,798,369

(a) For the fiscal years ending June 30.

The world's principal source of potash is the German Empire which has as yet a practical monopoly. Several of the mines are owned and operated by different German States, the oldest and largest being in Prussia. In addition, some of the largest mines are owned and operated by the Grand Duchy of Anhalt, and others by the State of Brunswick, where the Sollstedt works are. A few mines also exist in Saxony and in 1913 potash salts were imported from Alsace to the United States for the first time. The small shipments of 1912 were certified as coming from Brunswick. Recent developments have indicated that potash beds are much more widespread than has been so far believed. Stassfurt near the Harz has for centuries worked its salt mines. Wells were drilled by the government in 1839, and at first the bitter brines were considered worthless for salt. Rock salt mines discovered in other localities finally caused these wells to be abandoned. Efforts were then made by the

government to reach the salt beds from which these brines came. In 1857 at a depth of 1080 ft. after penetrating a large deposit of magnesia salts, the salt proper was encountered, but at this date the deposit of potash penetrated was considered worthless. To-day the average cost of producing a metric ton of kainite at Stassfurt is about $1.72; per ton of potassium chloride, $14.84; per ton of sulphate of potash, $21.38; and per ton of manure salt, $10.08.

The following table shows the production of potassium salts in Germany in recent years as officially stated:

PRODUCTION OF POTASSIUM SALTS IN GERMANY. (a)
(In metric tons and dollars; 1 mark = $0.238.)

Year.	Kainit.		Potassium Salts other than Kainit.		Potassium Chloride.		Potassium Sulphate.		Potassium Magnesium Sulphate.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		$		$		$		$		$
1898	1,103,643	3,835,856	1,105,212	3,576,628	191,347	6,380,220	18,853	763,397	13,982	259,485
1899	1,108,159	3,838,250	1,384,972	4,202,000	207,506	6,801,250	26,103	1,027,500	9,765	195,000
1900	1,178,527	4,134,000	1,874,346	5,643,750	271,512	8,793,750	33,853	1,249,250	15,368	280,500
1901	1,500,748	4,327,250	2,036,326	5,443,250	282,750	8,782,250	27,304	1,460,000	15,612	286,500
1902	1,322,633	4,571,980	1,962,384	4,949,448	267,512	7,507,710	28,279	1,079,092	18,147	334,390
1903	1,557,243	5,208,154	2,073,720	4,993,478	280,248	8,125,320	36,674	1,389,444	23,631	441,252
1904	1,905,893	6,322,470	2,179,471	5,305,972	279,238	8,425,676	43,959	1,664,572	29,285	545,972
1905	2,387,643	7,976,808	2,655,845	6,396,250	373,177	10,580,528	47,994	1,804,040	34,222	614,754
1906	2,720,594	8,918,574	2,821,073	6,538,336	403,387	11,034,632	54,490	2,032,520	35,211	644,028
1907	2,624,412	8,579,206	3,124,955	7,314,930	473,138	12,639,704	60,292	2,216,494	39,868	631,652
1908	2,715,487	9,196,082	3,383,535	7,720,006	511,258	13,369,174	55,756	2,037,518	33,149	663,068
1909	3,181,349	10,646,792	3,860,685	8,787,198	624,994	16,245,642	68,539	2,574,684	38,722	697,816
1910	4,249,667	12,712,056	4,062,004	9,034,004	741,259	17,371,144	84,583	2,989,756	37,439	668,066
1911	4,425,497	13,757,452	5,181,379	11,794,328	838,420	19,851,342	107,631	3,967,460	42,253	780,974
1912	5,889,238	18,178,916	5,271,964	10,294,214	506,744	16,336,792	123,407	4,848,714	54,435	(b)
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(a) From *Vierteljahrshefte zur Statistik des Deutschen Reichs.* (b) Value $1,052,912.

Exports of potash, actual weight, from Germany during 1912 and 1913, have been as follows:

Articles.	1912.		1913.	
	Metric Tons.	Value.	Metric Tons.	Value.
Carnallite with at least 9 per cent. and less than 12 per cent. K_2O.	6,853	$46,000	520	$3,000
Raw salts with 12 to 15 per cent. K_2O	853,117	4,094,000	1,124,816	6,697,000
Salts with more than 15 to 19.9 per cent. K_2O	35,530	286,000	49,687	404,000
Fertilizer salts, including potash fertilizer, with 38 per cent. K_2O.	373,685	5,510,000	460,865	7,855,000
Chloride of potash, not in shells or capsules	1,068	158,000	1,164	166,000
Sulphate of potash	85,749	3,660,000	133,358	5,700,000
Sulphate of potash-magnesia	48,600	1,085,000	59,207	1,339,000

The following is a distribution authorized for domestic and foreign consumption during the year 1914 in accordance with the provisions of

the potash-syndicate law (the amounts being in metric tons of pure potash, K_2O):

	For Domestic Consumption.	For Foreign Consumption.
	Metric tons	Metric tons
Carnallite with at least 9 per cent. and less than 12 per cent. K_2O	7,100	100
Raw salts with 12 to 15 per cent. K_2O	339,000	141,100
Fertilizer salts with 20 to 22 per cent. K_2O	2,300	48,300
Fertilizer salts with 30 to 32 per cent. K_2O	4,000	16,400
Fertilizer salts with 40 to 42 per cent. K_2O, including potash fertiliser with 38 per cent. K_2O	211,300	67,100
Chloride of potash	69,700	187,500
Sulphate of potash with more than 42 per cent. K_2O	1,700	55,000
Sulphate of potash-magnesia	200	15,800
Total	635,300	531,300
Grand total	1,166,600	

The potash law restricts only production for exportation. Each mine owner is bound to contribute the whole of his portion of the domestic consumption and not more than his portion of the foreign consumption. If the total for both domestic and foreign has been underestimated, it is changed in the course of the year. At the beginning of the year the first estimates exceed those of the preceding year by at least 5 per cent.

The price schedule of the syndicate for 1912 and 1913 is as follows:[1]

BAG SALT.

(In bags of 200 lb. net weight. No charge for bags.)

Muriate of potash, 80 to 85 per cent., basis 80 per cent	$38.05 per ton (2000 lb.)
Muriate of potash, min. 95 per cent., basis 80 per cent	39.65 per ton (2000 lb.)
Muriate of potash, min 98 per cent., basis 80 per cent	40.50 per ton (2000 lb.)
Sulphate of potash, 90 to 95 per cent., basis 90 per cent	46.30 per ton (2000 lb.)
Sulphate of potash, min. 96 per cent., basis 90 per cent	46.85 per ton (2000 lb.)
Double manure salt, 48 to 53 per cent., basis 48 per cent	24.45 per ton (2000 lb.)

BULK SALT.

Manure salt, min. 20 per cent. actual potash	$13.30 per ton (2000 lb.)
Hardsalt, min. 16 per cent., actual potash	10.65 per ton (2000 lb.)
Kainit, min. 12.4 per cent. actual potash	8.25 per ton (2000 lb.)

There is a regular and open system of rebates governed by the quantities purchased and payment being conditioned upon purchases being made exclusively from the Kali Syndicate.

One of the significant events of the year was the beginning of shipments to the United States from Alsace, the total for 1913 being valued at $584,189. Potash salts, in natural deposits, were discovered in Alsace in 1904 when deep borings were being made in the hope of striking oil. In 1909 the first kali mining shaft was completed in this district, and the following year 37,000 tons of kali salts were extracted. Since then other mines have been developed and the work has grown rapidly;

[1] American Fertiliser Handbook.

12 mines are now in operation in this district, three or four having been added during 1913, and the proportion of potash to be produced by these mines, as determined by the Kali Syndicate, is understood to be approximately 4 per cent. of the total annual German production, which is some 10,000,000 tons. About half of that amount is for home consumption and the other half for exportation. The United States takes nearly 50 per cent. of the total exports. Mulhausen has been created a "distributing center" for the potash industry.

In Alsace, so far as at present known, the deposits of potash underlie an area of nearly 7 square miles. They range in thickness from 6 to 30 ft. and contain an estimated 1,000,000,000 cu. yd. or 1,472,058,000 tons, of potash salts. On the basis of a 22 per cent. content of oxide of potassium the total Alsatian deposit may be considered to hold 300,000,000 tons of pure potash. It has recently been reported that the explorations in Baden, across the Rhine from the Alsacian potash mines, give encouraging indications of the extension of the potash deposits into that district also.

Potash in Other Foreign Countries.—There have been few changes in the potash industry in other countries and conditions are substantially as outlined in MINERAL INDUSTRY for 1912. In Belgium and England limited amounts of potash are made from wool grease, and as by-products of sugar manufacture. In Galacia potash is mined near Kalusz but not for export. The total annual output is about 1000 tons. The beds of kainit and sylvinit are said to be lens-shaped and to range in thickness up to 20 ft. with a potash content of 10 per cent. Galacia imports annually from Strassfurt, twice as much potash as the local production. In the south of France and also in Spain about 100 tons of KCl is annually made by direct evaporation from sea-water. Drilling was in progress during the year in the territory of Belfort, France, in hope of finding an extension of the Alsacian deposits. The Reppe well penetrated to a depth of 550 meters when an accident stopping drilling in December. Other wells were being drilled at Chavannes-les-Grands, Charmois, and Suarce, but no results have yet been announced. In Spain it was announced that a French syndicate had found irregular but probably important deposits of carnallite, sylvinite, kieserite, and rock salt near Barcelona, and would proceed at once to vigorous development.

Niter deposits from India, Chile, and Africa furnish potash salts in relatively small amounts. The exports from Bengal are estimated at less than 10,000 tons per annum while perhaps twice as much was produced by workings in Chile. Of the various projects for making potash from phonalite, in Iceland, Italy, and elsewhere, there is nothing new to report. In Scotland, Norway, and Japan potash and iodine are made

from kelp, though in a relatively small way, and in Russia potash carbonate is made from the ashes of sunflower stalks. In Canada wood ashes from the big lumber mills is still an important source of supply for alkali works. It must be confessed, however, that outside the United States, the possibility of successful competition with the Kali syndicate rests more and more on the chance of finding by drilling beds of salt similar to those worked at Stassfurt.

Potash Deposits in the United States (By H. Foster Bain).—During the year the search for a local supply of potash went forward vigorously and at several points drilling, and even construction work, is under way. Actual manufacturing is as yet only on an experimental scale. The most probable source of early production is Searles Lake, California, where the American Trona Corporation is building works which are expected to begin marketing potassium chloride in January, 1915. Searles Lake is a dry lake or *playa* lying between the Slate and Argus ranges in the northwestern part of San Bernardino County, California. It is about 25 miles from Searles, a station on the Mojave-Owenyo branch of the Southern Pacific, with which it is now connected by the Trona railway, a well-built, standard gauge line financed by the American Trona Corporation, and placed in operation in April of this year. The lake is best known as Borax Flat from the circumstance that the mud surrounding the crystal body proper, was formerly the source of material for manufacture of borax by the California Borax Co. The old works, built by John W. Searles and later sold to the San Bernardino Borax Co., one of the F. M. Smith interests, stood idle for a number of years. About 1904 they were leased to the California Trona Co. which was formed by C. E. Dolbear and associates to manufacture soda ash from the trona which forms a conspicuous part of the crystal body, near its south edge. Mr. Dolbear's company borrowed money from the Foreign Mines Development Co., an offshoot of the Consolidated Gold Fields of South Africa, Ltd., and for which Guy Wilkinson acted as local manager and Francis Drake as consulting engineer. For various reasons, not well understood and the occasion for much dispute, the California Trona Co. failed in its plans for making and marketing soda and found itself unable to repay the loan contracted. The Foreign Mines Development Co. took judgment and threw the property into the hands of a receiver, but never proceeded to have it sold. Instead Mr. Wilkinson and his associates purchased stock of the bankrupt California Trona Co., until they now hold 90 per cent. of the shares. In the meantime various options on the property had been given either by the old or new owners, and numerous efforts had been made to dispose of it. A number of examinations were conducted, especially a very elaborate one made by Smith, Emery & Co. for F. S. Pearson. Another was made for the Solvay

Process Co., all being directed toward determining the value of the property as a source of sodium salts.

The mineral hanksite was described from this locality as early as 1889 and though the first analyses were a trifle confusing, it was known to contain potash. In 1898 Whitman Symmes recognized the presence of potassium in the brine and suggested the probable value of the lake as a source of potash. He had numerous analyses made but so firmly fixed was the idea that there was no potash in the United States, that nothing came of the suggestion. It was not until one of the examining engineers working for Pearson studied the material that the importance of the presence of potassium was recognized. His suggestion came after Smith, Emery & Co. had completed their examination, but a number of analyses, made both in San Francisco and the east, demonstrated the presence of potash in amounts of probable value. This fact became known to various people including E. E. Free, at that time connected with the U. S. Department of Agriculture and coöperating with the U. S. Geological Survey in a special search for potash in the United States.

In company with Mr. Wilkinson, Mr. Free, and Mr. H. S. Gale representing the U. S. Geological Survey, visited six wells on the property in May, 1912, and procured samples of the brine which was analyzed in the laboratory of the Mackay School of Mines at Reno, Nevada, and checked in the Geological Survey laboratory at Portland, Oregon. A preliminary announcement was made at the time but these analyses have only been published in full this year, appearing in an excellent general account of the saline lakes of the west prepared by H. S. Gale.[1] The analyses are summarized below:

COMPOSITION OF BRINE FROM SEARLES LAKE, CALIFORNIA.
(Percentage of ignited residue. Walton Van Winkle, analyst.)

	Austin well U.	Well W9.	Well S.E. No.8.	Austin well O.	Well S.E. No. 7	Well S.E. No. 4.	Average.
SiO_2	0.05	0.03	0.00	0.00	0.00	0.03	0.02
As	0.06	0.06	0.05	0.06	0.06	0.08	0.06
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	33.37	23.57	33.16	33.92	33.23	32.90	33.19
K	6.53	7.27	5.98	5.54	6.29	5.69	6.22
CO_3	7.37	7.95	6.65	6.89	6.85	6.94	7.11
SO_4	12.00	12.49	13.41	11.89	13.79	13.00	12.76
Cl	35.97	35.53	36.50	37.13	36.40	36.79	36.39
B_4O_7	3.07	1.58	1.77	2.03	2.08	4.14	2.45
Total	98.42	97.48	97.52	97.46	98.70	99.57	98.20
Total salts (ignited residue, percentage of original sample)	33.48	33.94	33.30	32.96	33.21	32.88	33.30
Specific gravity	1.3002	1.3045	1.2969	1.2935	1.2959	1.2932	1.2974

[1] *Min. Res. of U. S.*, 1912, pp. 884–893.

With regard to the samples Mr. Gale says:

"Each sample was collected by lowering a stoppered and weighted bottle to a depth of 35 to 40 ft. in the brine and then, by means of a separate cord provided for the purpose, jerking out the stopper and allowing the bottle to fill.

"By re-calculating the average results of these six analyses to a theoretical or possible combination of salts that might be derived therefrom the following result is obtained. This is the approximate composition of the anhydrous residue which results from the complete desiccation of the brine.

HYPOTHETICAL AVERAGE COMPOSITION OF ANHYDROUS RESIDUE OF BRINE FROM SEARLES LAKE BASIN.

	Per cent.
Sodium chloride ($NaCl$)	51.61
Sodium sulphate (Na_2SO_4)	19.22
Sodium carbonate (Na_2CO_3)	12.79
Sodium biborate ($Na_2B_4O_7$)	3.23
Potassium chloride (KCl)	12.07
Sodium arsenate (Na_2AsO_4)	0.17
	99.09

"The original brine contains a variable percentage of bicarbonate, which is converted to the carbonate form in the anhydrous residue and is so expressed.

"As is well known, the theoretical composition of salts in the brine, as shown by the calculations from the analyses, can be accepted as a working basis only with certain reservations. Doubtless most of the salts named in the conventional method of computing the analysis of a solution may be abstracted from the brine somewhat in the proportions given, provided that satisfactory chemical processes can be devised to accomplish the desired result. It is believed that this has already been at least partly accomplished experimentally. But it is also true that no practical process of extraction on a commerical scale will derive all these salts in the amounts shown."

In the preliminary press bulletin issued by the Geological Survey in 1912 the general results, but not the analyses, were given and attention was immediately attracted to the deposit. The land was withdrawn by presidential order at the same time, though, since the withdrawal did not touch existing titles, it did not affect claims on the salt body, which had been previously fully covered by locations made for the California Trona Co. Mr. Wilkinson had already cancelled all options outstanding and was making vigorous efforts to develop the property for the production of potash at the time these samples were taken. John W. Hornsey was employed to study the material and devise a workable process. Studies made first in the laboratory in New York and later confirmed by large scale experimen-

tal work in the old borax plant at the lake showed that it would be possible to treat the brine economically and to recover soda ash, salt, sodium sulphate, borax, and potassium chloride. In June, 1913, when Mr. Hornsey's report upon the process and the project was available, the American Trona Corporation was formed[1] to manufacture and sell these salts for the California Trona Company in which it acquired controlling interest. The new Corporation was backed by the Consolidated Gold Fields group, joined by American capitalists who hold a minority interest. A larger share in the enterprise was offered to the Americans but was not taken, mainly owing to the apparently antagonistic attitude of the government at Washington. The Trona Corporation has financed the building of the railway just completed, the development and assessment work necessary to perfect title to the claims on the lake, the purchase of non-mineral land for mill and townsite, and the active research work directed to perfecting the mechanical details of the plant now being built. All this work has gone forward steadily and approximately $2,000,000 has been spent already on the enterprise.

Owing to the fact that patents have not yet been taken out upon all details of the process and plant, it is impossible to give at this time a complete description. Briefly, however, the process involves evaporation by artificial heat in a series of horizontal revolving driers, such control being exercised over dilution and temperature as to bring down the various salts in sequence, the potash being last. To facilitate extraction of the sodium carbonate it is first treated with CO_2 in a closed cylinder under pressure converting the mono-carbonate into bi-carbonate which, at the temperature, dilution, and pressure used, is insoluble. The solution is then passed through Dorr thickeners and Caldecott filters to remove the carbonate crystals. They are later heated in another chamber and the CO_2 recovered. The solution from the CO_2 chamber passes through successive evaporators and filters to remove the sulphate, salt, borax, and finally the potassium chloride. All these steps have been accomplished on a more than laboratory scale and the salts are made on a tonnage basis in a full-sized evaporator now in use at Trona. The present plant consists of evaporators and other machines of standard size. The purpose of the present work is to learn by actual use of full-sized machines such details as most economical angle of slope, rate of speed, size of furnace, etc., so that the numerous machines needed in the large plant about to be built may be designed for maximum economy and efficiency. For example, the evaporators in the present plant rest on a hinge joint at one end and jack screws at the other so that the slope may be varied at will until exactly the right angle be found for each step in the work. The experi-

[1] *Min. Sci. Pr.*, June 14, 1913.

mental work is under control of a competent force of chemists and engineers working with an unusually complete laboratory, and designing of the big plant is under way.

The material to be used is the brine, which will be pumped from the interstices of the crystal body as needed by means of wells of which a large number has been already completed. More than 500 samples of the brine have been studied. A representative analysis is quoted below:

Sample S 14 taken at a depth of 10 ft.

	Per cent.
$Na_2B_4O_7$	1.55
$NaHCO_3$	0.25
Na_2CO_3	4.76
NaCl	15.84
$NaSO_4$	6.72
KCl	4.36
Total solids	33.48

The specific gravity of this sample was 1.2976 at 15.5° C., and the total solids by evaporation, 34.42. The sample shows rather less borax than usual, it being estimated that the latter averages 2.93 per cent. It will have been noted that in the brine samples of the Geological Survey the potassium content is higher and that there is a variation of as much as 10 per cent. in the amount found. While samples taken in the crystal body proper are remarkably uniform, when allowance is made for occasional surface water due to rains, and for temperature, there is marked variation in the composition of brines taken from the surrounding mud flats and land. Some of these contain borax and other salts in excess and others are deficient. It is estimated that natural evaporation at the lake amounts to 0.25 to 0.50 in. per day. Since the level is constant it follows that the lake is fed by underground flow from the surrounding mountains, and that the brine in the crystal body acts as an equalizer to the incoming water. The crystal body itself varies greatly in composition from point to point and in depth, though all the salts involved may be found in some quantity at any point on its surface. Speaking in broad general terms, the surface is predominately common salt. Below this are the layers in which carbonate and sulphate of soda predominate and the potash seems mainly to lie on the border line. The borax is most common in the basal layers and the mud which lies below and around the pure salt. The brine is free to move through the mass and preliminary pumping experiments indicate that, away from the edge, a constant flow can be obtained without deterioration in grade. Various tests made by Mr. Hornsey indicate a pore space in the crystal mass of 40 to 45 per cent.

The plant now under construction, and which is expected to be in operation by January, will have a capacity of 1 per cent. of the final works

which is to evaporate 2,000,000 gal. per day. Upon completion of the pilot plant the main works are to be built in four units. It is estimated that the brine required will be equivalent to 0.1 in. per day over the lake or much less than the natural evaporation. As the area of the lake is measured in square miles, the crystal body 70 ft. deep, and the salty muds extend to at least 700 ft., it is evident that an abundant supply exists. The daily output of the completed plant will be: borax, 225 tons; soda ash, 508; salt, 1507; sulphate of soda, 593; potassium chloride, 489. For revenue, the company will necessarily depend upon the potash, soda ash, and borax. A part of the salt may be marketed, and in time uses for the sodium sulphate may be found, but for the present these may be neglected. It is stated that the policy of the company will be to disturb existing industries as little as may be, and to be "manufacturers for manufacturers." However this may be in theory, profound changes are inevitable. Mr. Hornsey's report and estimates have not been made public, but examination of them and the works indicates that the cost will be low; so low that the new company expects to undersell any important competitor. The soda ash is mainly to be marketed abroad, and especial efforts are to be made to capture the Oriental markets. The potash will be marketed as a chloride, at least for the present, and will go to the eastern and southern states. The amount now contemplated is less than the annual importation from Germany of this salt alone and would furthermore be absorbed by the natural growth of the American market in five years, at the rate obtaining in recent years. There is, therefore, ample room for sale of all that will be produced without provoking the sharp antagonism of the German producers of other potassium salts. The limiting factor as regards output is the borax. While there are no exact and complete figures covering the borax industry, the United States output of borate of lime amounted in 1912 to 42,315 tons. Imports of borax were 9280 tons and of borates 16,091 tons. The new concern will be prepared to manufacture about 90,000 tons of borax, and the cost is a matter of bookkeeping. A lower price would increase consumption of borax in the dyeing industries, and possibly in other directions, and it is manifestly to the advantage of the Trona company to stimulate the use in every way possible. From the point of view of this concern the borax is a by-product. It must be taken out of the solutions in order to get at the potash so that any price covering the cost of handling can be made. At present there is a contract between the California Trona Co. and the Pacific Coast Borax Co. whereby each has an option on the minor product of the other; the Trona Company agreeing to sell to the Borax Company all borax made and the Borax Company optioning any soda made by it to the Trona Company. This contract expires in 4 years and is ter-

minable before. Since the amount of borax that the Trona Company will offer is so much larger than was anticipated when the contract was made, it is doubtful whether the option will be exercised. In the meantime F. M. Smith, who holds controlling shares in Borax Consolidated, is in financial difficulties, and almost anything may happen in the borax market.

Other attempts to develop potash deposits in other *playas* of the West are in a less advanced condition, though drilling is in progress at several points. Within the year the U. S. Geological Survey reported upon the drilling of four wells recently completed in Death Valley, California.[1] Samples of 11 brines were analyzed, with the result that 0.51 to 1.27 per cent. KCl was found in the original brine. The average was 0.94 per cent. These were essentially saturated brines, the principal dissolved constituent being sodium chloride. The potash content is not unusual in any way, being about the average generally found in natural brines or saline residues in the desert basins.

It does not appear that there is much theoretical justification for the belief that such deposits must be present in Death Valley. It is, of course, possible that the present conclusions are based on insufficient negative evidence, and for this reason any further drilling that may be carried on by private claimants in the Death Valley region should afford a record of much importance and interest in this connection, and it is hoped that good records will be kept.

Subsequently, drilling was continued by D. H. Walker for persons closely affiliated with the Pacific Coast Borax Co. and under date of February 19, 1914, it was reported that a hole had been carried to a depth of 1000 ft. in Section 30, T. 25 N., R. 2 E. The entire well was reported to show a series of hard salt strata, each from 1 to over 20 ft. thick, alternating with similar strata of clay or mud, all more or less salty. From the surface to about the 250-ft. level the salt is essentially sodium chloride. From this level to the bottom of the well the salts are essentially sulphates, principally sodium. From the 850-ft. level to the bottom, the well shows much more clay and less salt. No significant potash results are reported. The chemical and mineralogical record was regarded as too incomplete and the well is too shallow to justify any opinion concerning the prospects in the valley for commercial potash or soda carbonate. The aggregate of solid salt strata found was about 400 ft. or 40 per cent. of the total section penetrated, but this figure would be greatly increased if the salts scattered in the clays were included. Death Valley well No. 2 is now being drilled by Mr. Walker, about 6 miles north of well No. 1. It is expected that this well will be drilled somewhat

[1] *Min. Sci. Pr.*, May 24, 1913.

deeper than well No. 1, and that a better mineralogical record will be kept.

The most elaborate and persistent attempt to find potash by drilling has been made by the Railroad Valley Co. operating in Nye County, Nevada. Over 10,000 ft. of drilling has been done and $115,000 has been spent. E. E. Free, the consulting expert of the company, gave a general resume of the work in the *Mining and Scientific Press* for August 2, 1913. This was supplemented by a later report made to a special meeting of the stockholders held at Tonopah, February 10, 1914.[1] The effort has been to test the theory that the valley was formerly occupied by a lake that was evaporated to dryness and to find the residual body of crystalline salts. Much has been found to confirm the theory and incidentally a body of gaylussite ($Na_2CO_3.CaCO_3.5H_2O$) has been found which is, of itself, of possible economic importance.

Within the year the United States Geological Survey has published an excellent general summary of the situation at the close of 1912[2] including an account of the saline lake of the West by H. S. Gale. Another important paper "Potash in Western Saline Deposits" by James H. Hance,[3] includes analyses from many localities. Especial interest was directed during the year to certain shallow lakes in the sand-hill region of Northwestern Nebraska where potash bearing brines are found. The average of 13 samples of the brine, according to Mr. Hance, was 24.91 per cent. K_2O expressed as content of dissolved salts, and 7.69 per cent. of dissolved salts in original sample Similar averages of 6 samples of mud and of 8 samples of saline residues were: muds, 19.86 per cent. K_2O, soluble portion 4.69 per cent.; residues, 14.73 per cent. K_2O, soluble portion 19.55 per cent. J. H. Show[4] reported the following analyses from Jesse Lake, 2 miles from the Burlington railroad and 12 miles from Alliance.

Total Solids in Solution.

Mar. 21, 1910. North Shore. 16.25 Per cent.		Sept. 25, 1911. East Shore. 16.42 Per cent.		Nov. 23, 1912. South Shore. 14.17 Per cent.	
North Shore. 3-21-1910.	Per cent.	Salts in Solution Showed East Shore. 9-25-1911.	Per cent.	South Shore. 11-23-1912.	Per cent.
K_2O	28.50	K_2O	28.34	K_2O	28.27
Na_2O	27.64	Na_2O	27.94	Na_2O	27.25
CO_2	20.17	CO_2	21.27	CO_2	19.45
$HCO_2 1/2$	7.59	$HCO_2 1/2$	7.31	$HCO_2 1/2$	9.47
SO_3	12.09	SO_3	11.73	SO_3	13.09
Cl	4.00	Cl	3.40	Cl	3.23
	99.99		99.99		100.76

Crystals of potassium sulphate commence to separate out when a 28 per cent. total solids is attained.

[1] See *Min. Sci. Pr.*, February 7 and 14, 1914.
[2] W. C. Phalen, "Potash Salts: Summary 1912," *Min. Res. of U. S.*, 1912, pp. 899–908.
[3] U. S. Geol. Surv., *Bull*, p. 540.
[4] *Chem. Eng.*

While the lake is usually dry a well 8 ft. square and 8 ft. deep, 200 yd. from the shore line flowed 1000 gal. strong brine per hour. About 20 lakes in the vicinity investigated by Mr. Show indicated a total area of 5000 acres. Experimental work on the reduction of the brine is now under way. It is assumed that the potash in the lakes has accumulated by natural leaching by rain water of the wood ashes resulting from frequent prairie fires.

Potash is reported from near Granger, Wyoming, where it occurs mixed with other alkalies in a crust over shales and clays. The amount available has not been determined.

Attempts to make potash from kelp are still under way but the immediate utilization of the material seems more likely to be in the form of chopped and dried kelp itself. The giant kelp groves of the Pacific coast, according to F. K. Cameron of the U. S. Department of Agriculture, have now been surveyed from Puget Sound to Cedros Island. Approximately 230 square miles of kelp groves has been charted and the possible yield is estimated at 22,000,000 tons of wet kelp, equivalent to 1,000,000 tons KCl. Remembering the difficulties involved in handling and drying peat, the possible profit from handling 22 tons of wet kelp to get one of salt, does not seem impressive. However, Mr. Cameron reports that a successful harvesting machine has been constructed and that working at San Pedro, on a basis of 500 tons per day, the actual cost is 20 cents per ton. The dried kelp contains 15 per cent. K_2O and 2 per cent. of easily available nitrogenous matter. Estimates as to cost are conflicting and as yet production is small. In comparing this possible industry with that already established in Scotland and elsewhere, it is well to remember the differences in labor conditions and also in yield. Furthermore the possible revenue from iodine is problematical since the present consumption is small. If iodine could be made for a low cost it would be valuable in the treatment of gold ores but its general use is out of the question at present. The concession granted by the Mexican government for harvesting kelp on the west coast, has apparently lapsed for non-use.

In regard to the use of alunite as a source of potash there is little new to report. New sources of material in Arizona and Nevada have been reported[1] but the best chance of success seems still to be at Marysville, Utah. The mining and refining problems are being studied and the property is in strong hands. It is aparent, however, that the material must be treated primarily as an aluminium ore, the potash becoming a by-product. This complicates the matter since entrance into the aluminium market is not to be rashly ventured.

At Riverside in southern California a potash-bearing dust is being

[1] Schrader, F. C., U. S. Geol. Surv., *Bull.* 540-1.

collected as a by-product from the manufacture of portland cement. Orange growers in the vicinity having complained of the dust from the stacks of the cement works, the Cottrell electrical precipitation apparatus was introduced to clean the smoke. The dust was found to be surprisingly rich in potash and is being bagged and sold to the same farmers who made the original complaint.

At Chester, Pennsylvania, it is understood that a small plant is in operation leaching potash from feldspar but technical details have not been made public.

One feature of the year not to be passed over was the attempt at Washington to secure a general leasing law under which potash lands now reserved or hereafter found on the public domain might be developed. At this writing it appears unlikely that this law will be enacted. Instead a code commission has been proposed to consider revision to all the mineral land laws of the United States.

Bibliography

Bentz, B.—Die Versorgung der Vereinigten Staaten von Nordamerika mit Kali. *Glückauf*, Aug. 16, 1913, p. 1291.

Cameron, F. K.—Kelp and Other Sources of Potash. *Jour. Frank. Inst.*, Oct., 1913, p. 347.

Cameron, F. K.—Possible Sources of Potash in the United States. *Am. Fertilizer*, July 12, 1913.

Ebaugh, W. C.—Phosphates, Potash and Nitrates. *S. L. Min. Rev.*, May 15, 1913, p. 22.

Geyler, W.—Die Verwendungsmoglichkeit von Schaufelbaggern in Kalibergwerken. *Kali*, Dec. 15, 1912, p. 612.

Görres, Dr.—Vorschläge zur Verbesserung des Kaligesetzes. *Bergwerks-Ztg.*, June 15, 1913, p. 1; June 17, p. 1.

Herbing, Dr.—Ueber Erdgas, Kali und Petroleum in Sieberbürgen. *Zeit. Internat. Vereins Bohringenieure & Bohrtech.*, Feb. 15, 1913, p. 39; March 1, 1913, p. 49.

Jänecke, Dr.—Vorschläge zur Fortsetzung der van't Hoffschen Forschungen. *Kali*, Aug. 15, 1913, p. 393.

Leimbach, Gottelf.—Ueber die Anwendung elektrischer Schwingungen zur Erforschung des Erdinnern, besonders im Kahbergbau. *Kali*, Sept. 1, 1913, p. 433.

Maenicke, B.—Die Verwendung von auswechselbaren Bohrschneiden im Kalibergbau. *Kali*, Dec. 15, 1913, p. 603.

Meuskens, Cl.—Stationäre Pumpenanlagen in Kaligruben. *Kali*, Aug. 1, 1913, p. 377.

Rohland, P.—Die Endlaugen der Kaliwerke. *Chemicher-Ztg.*, Nov. 25, 1913, p. 1448.

Rosenkronzer, F.—Das Kalivorkommen im Oberelsass. *Berg. Hüttenm. Rundschau*, Aug. 20, 1913, p. 279.

Sonnenschein.—Das Kalivorkommen im Ober-Elsass. *Bergbau*, Dec. 5, 1912, p. 687.

Stutzer, A.—Amerikanisches Kalisalz. *Kali*, Feb. 1, 1913, p. 50.

SURR, GORDON.—Notes on Kelp and Its Potash Contents. *Min. Eng. World*, Mar. 8, 1913, p. 488.

————.—Sources of Potash: How Ancient Lake Beds Were Formed. *Min. Eng. World*, May 10, 1913, p. 910.

————.—Die Kalivorkomen in Südwest Deutschland. *Zeit. Internat. Verein. Bohringenieure*, Oct. 1, 1913, p. 225.

————.—Die Möglichkeit der Auffingung von Kalilagern in Siebenbürgen. (*Zeit. Verein. Bohringenieure*, Sept. 15, 1913, p. 214.

————.—Imports of Potash Salts in the United States. *Min. Sci. Pr.*, July 5, 1913, p. 12.

————.—More Potash Legislation Looked For. *Eng. Min. Jour*, Feb. 22 1913, p. 432.

————.—Potash Production Assured. *Min. Sci. Pr.*, June 14, 1913, p. 888.

————.—Prospecting for Potash in Death Valley, California. *Min. Eng. World*, May 31, 1913, p. 855; *Min. Sci.*, May, 1913, p. 268.

PRECIOUS STONES

By George Frederick Kunz

During the past year the sapphire has more than retained its popularity and has been the king gem for the time being. Fine emeralds, however, have held their own, and diamonds have of course maintained the place they have always occupied as standard gems, but little dependent upon the chances and changes of fashion, except as to the form of cutting.

What are known as "phenomenal gems" because they show a moving ray or rays, have enjoyed the highest favor, more especially moonstone with a bluish light, as well as the varieties of asteria, star-sapphire and star-ruby.

Rock crystal, rounded and domed, to which a dull polish has been given, or where the polish has been so dulled as to make the crystal resemble moonstone, has been much appreciated, such stones being in many cases pierced and incrusted with diamonds and other gems; often they are engraved and provided with a bordering of diamonds.

The calibre-cut onyx, used to form a dainty line or tracery, defining a line of diamonds, has been exceedingly popular.

The revival of the fashion of wearing necklaces or strings of beads has been very marked during the past year, and the taste for this form of ornament appears to be gaining ground daily. While this has contributed to restore amber to public favor, so that the price of the material has risen 25 per cent. or more within a short time, and many amber stocks have been almost depleted, the most popular beads are those of chalcedony, carnelian, lapis-lazuli, amethyst, chrysoprase, topaz, rock crystal, pink quartz, moonstone, etc.

Markets and Imports.—The London market[1] for rough diamonds, after a period of retrocession in the latter part of 1913, showed marked signs of recovery in January, 1914. Generous buying, largely by American interests, had cut down the accumulated stocks of cut diamonds in Amsterdam and Antwerp, and encouraged freer purchases of the rough materials. A prudent marketing of this by the diamond-mining interests has also greatly contributed to steadying the market. There has been a disposition to offer only good assortments for sale, and a continuance of this policy will, it is believed, warrant a raise in price, an increase of returns secured in this way being regarded as much preferable to that obtained by asking

[1] Financial News of London, Feb. 14, 1914.

and obtaining the same price for a poorer assortment of diamonds. The necessity for careful handling of the diamond market is apparent in view of an estimated production of $60,000,000 worth of African diamonds from the African fields in 1913, this comprising the product of all the African mines, including those of the German Protectorate.

The diamond trade of Amsterdam with the United States fluctuated in volume during the year 1913 in response to the new tariff agitation and the uncertainty as to the date at which the almost inevitable higher rates would go into operation. On the whole the effect was temporarily favorable as to exports, to a moderate degree, the figures for cut stones being $10,085,700 for 1913 as compared with $9,790,694 for 1912, an increase of nearly $300,000. The rough-diamond exports showed a slight falling off, declining from $985,161 in 1912 to $854,595 in 1913. Of course the special conditions of the trade were reflected in the diamond labor market, the eventual result being on the whole somewhat unfavorable for the local diamond-cutters. However, the check put upon the continual advance in the scale of wages that has been attained by the Amsterdam Diamond Workers' Union during the past 10 years, operates to make it easier for the Dutch manufacturers to compete with their dangerous and enterprising Belgian rivals. The unemployed workers in Amsterdam in the month of December, 1913, are said to have numbered 4600, or about 60 per cent. of the trade; however, as most of them received high wages for the nine prosperous months of the year at least, their situation was probably not as bad as it might seem to be; the highest number of unemployed at any time during 1912 was 3400. On the whole prospects are considered good for 1914, in spite of the higher tariff. The market for rough stones which was rather demoralized by a surplus of German diamonds, expects relief from a proposed restriction of the quantity of these diamonds to be marketed, so as to keep prices steadier and impart greater confidence to buyers.[1]

The exceptionally heavy imports of diamonds into the United States in 1913 were reflected in the Antwerp trade as is shown by the following figures for the years 1910-1913.

	Cut Diamonds.	Rough Diamonds.	Total.
1910	$10,061,843	$795,195	$10,857,038
1911	10,009,324	1,348,151	11,357,475
1912	9,665,027	1,238,867	10,903,894
1913	11,019,180	2,355,294	13,374,474

As will be noted the increase is even more marked in the case of uncut than in that of cut diamonds. The Antwerp market is said

[1] D. P. De Young, *Daily Consular and Trade Reports*, Feb. 12, 1914, pp. 564, 565.

to have taken more than 100,000 carats each month of 1913 from the German African fields, practically the entire output. These very small diamonds, known as mêlés, came in so fast that the diamond cutters could scarcely keep up with the shipments. The average price secured by the German Diamond Regie was $10.94 a carat, and as 760,000 carats' weight of these stones came to Antwerp during the first half of 1913, the cost of this rough material received during that period was about $8,500,000. Of the different German mining companies, the largest share was contributed by the Pomona Co., which furnished 316,423 carats' weight in 6 months' time. The necessity for regulating and limiting the supply of these small stones is easily apparent in view of the statement that for the entire year 1913, diamonds to the weight of 1,440,000 carats were sent to Europe from the German fields. The De Beers Co. has so far carefully guarded the interests of their customers in the smaller class of goods by strictly limiting the amount to be marketed by the Syndicate in London, but all efforts in this direction would have been unavailing and might have had to be abandoned if some concurrent action on the part of the German diamond distributors had not been attainable.

The slight lead secured by Antwerp over Amsterdam in the diamond industry some 5 years ago and maintained since then, was somewhat accentuated last year, as is indicated by the following figures, giving the diamond exports to the United States from these two ports for the years 1905-1913:[1]

	Amsterdam.	Antwerp.
1905	$10,425,814	$6,465,464
1906	12,435,161	6,448,894
1907	7,905,852	6,283,576
1908	4,571,804	4,408,366
1909	12,441,243	12,914,793
1910	10,655,753	10,857,038
1911	10,080,851	11,357,475
1912	10,645,289	10,903,894
1913	11,070,862	13,374,474

As forecasted in our last report, the importation of diamonds was phenomenal during 1913, this being due, in accordance with our anticipations, to the expected advance in duties from 10 per cent. to 20 per cent. *ad valorem* on the cut stones, and from 3 per cent. to 10 per cent. on uncut diamonds; these new and higher rates have been imposed since 1913. The large increase in the stocks of diamonds held by dealers caused by these unusually heavy imports very naturally resulted in a curtailment of

[1] Henry W. Diederich, *Daily Consular and Trade Reports*, March 28, 1914, p. 1171.

imports in the opening months of 1914, although financial stagnation has augmented this.

The general trend of the importation of diamonds and other precious stones into the United States during the past 4 years (1910-1913) can be best understood by a comparison of the official figures for this period.

IMPORTS OF PRECIOUS STONES FOR THE YEARS 1910, 1911, 1912, 1913.

	1910.	1911.	1912.	1913.
Diamonds, uncut, including miners', glaziers', and engravers', not set. Free	$9,204,134	$9,854,152	$9,863,770	$11,616,286
Diamonds, uncut. Dut	.....	.....	.....	956,576
Diamonds, cut but not set. Dut	25,672,639	25,705,563	22,876,042	24,786,133
Pearls and parts of, not strung or set. Dut	464,712	1,387,689	5,139,406	5,004,489
Other precious stones, uncut. Free	222,513	109,241	115,812	47,716
Other precious stones, uncut. Dut	.....	.....	.....	9,459
Other precious and semi-precious stones, cut, but not set. Dut	6,751,832	4,519,263	3,342,219	2,740,804
Imitation precious stones. Dut	.....	587,256	1,215,471	1,299,145
	$42,315,830	$42,163,164	$42,552,720	$46,460,608

IMPORTS OF DIAMONDS AND OTHER PRECIOUS STONES, AND OF PEARLS INTO THE UNITED STATES FROM 1867 TO 1908.

Diamonds: glaziers', miners', and engravers', not set	$3,277,209
Diamond dust	6,787,740
Diamonds, rough or uncut	83,994,001
Diamonds, set	53,969
Diamonds, cut, but not set	152,784,223
Diamonds and other stones, not set	211,556,278
Pearls	20,120,798
Total	$478,574,218
Imports from 1909 to 1913	217,062,878
Grand total	$695,637,096

Of these imports, totaling nearly $700,000,000, it can safely be said that the value of the diamonds for ornamental purposes represents almost $600,000,000 and that of the pearls from $30,000,000 to $35,000,000.

On July 1, 1914, the international metric carat of 200 milligrams will have been in use officially and in the trade generally for one year's time. It has amply proved its usefulness in the following ways: Simplicity in weighing, facility in calculation, simple denominations, and correctness of entries in stock books, and it would be impossible to make the dealers return to the older and more cumbersome carat.

Some brief notes as to the general production of precious stones in the United States may be offered here. A few diamonds have been mined in

Arkansas, in experimental development, but not enough to call them a commercial production. Montana sapphires have been mined and sold in greater quantities than ever before, this result being due to the fact that the sapphire has enjoyed more popular favor than any other precious stone; many of the Montana sapphires of a carat or less in weight, rarely more, retain their blue color by artificial light, whereas many of the Asiatic sapphires assume a too dark hue under these conditions. Rubies are not found in the United States, neither is alexandrite nor transparent chrysoberyl. Topaz, white and of pale hue, has been found at Streator, Texas; but few, however, are cut into gems, the best specimens being generally sold for mineralogical collections.

Several mines in San Diego Co., California, and in adjacent counties in that state, have produced magnificent tourmaline crystals, constituting superb red, green and yellow gems, and a quantity of fine large kunzite crystals have also been brought to light in San Diego Co., near Pala. Garnets, mostly of gem quality, have been found in Arizona and New Mexico, and also peridots, but in sparing quantities. Turquoise, known to occur in so many localities, has been but little mined, and few gems in the finer blue colors have been sold recently, the sales comprising mainly the poorer and cheaper varieties, often worked up into beads.

A great variety of the lesser gems—moss-agate, chrysoprase, the various colored agates, and the beach pebbles—have furnished considerable work to the lapidary. These beach pebbles have often been sold, not for what they really are, but under some ideal name, such as moonstone, or else have been endowed by the local lapidaries with some altogether fanciful name, having no place either in scientific nomenclature or in gem lore.

Taken altogether the value of the precious stones produce in the United States scarcely amounts to more than 1 per cent. of the total value of the gems sold in our country, but none the less they are both scientifically and artistically interesting.

For full data on the subject of Precious Stones in the United States, see the articles in the reports of the Department of Mining Statistics of the United States Geological Survey, issued annually. The articles on Precious Stones were written by George Frederick Kunz from 1882 to 1905, and later by Douglas Sterrett from 1906 to 1913.

The following are other publications of George Frederick Kunz:

United States Census Reports, 10th and 11th, 1890 and 1900.
Gems and Precious Stones of North America, New York, 1889–1892, pp. xii, 363.
The Gems and Jewelers' Minerals of California.
The Precious Stones of North Carolina.

DIAMONDS

Africa.—At the twenty-fifth annual meeting of the De Beers Consolidated Mines, the chairman, Mr. Francis Oats, called attention to the large increase in African diamond production in the past year. While the output of South Africa, including the German fields, for 1912 (to June 30), was 5,642,230 carats, during the year ending June 30, 1913, the same region produced 6,483,000 carats of diamonds, an increase of 840,770 carats. The amount paid by the purchasers for the diamonds marketed in 1912 to 1913 was £13,400,000 against but £10,169,000 in 1911–12, a difference of £3,231,000, showing that considerably higher prices were realized in addition to the larger quantity; the augmentation of value for the De Beers product was set by the chairman at 10 per cent. He makes a strong appeal to the producers of the smaller diamonds so profusely marketed during the past year, to exercise a salutary self-control and not to overstock the market with this inferior class of goods and risk a consequent disturbance of prices, which might work great injury to them, for as surface deposits become exhausted and deep mining becomes necessary the cost of production is greatly increased, and hence the producers of small diamonds would be in a very disadvantageous position were the prices for this inferior class of stones not maintained. The conservative policy of the De Beers Co. is strikingly exemplified by the fact that since 1908 the De Beers mine has not been worked, although as good a profit could have been realized here as in some of the other mines exploited by the company.

The financial operations of the De Beers Consolidated Mines, Ltd., for the 12 months ending June 30, 1913, show a distinct and marked advance as compared with those of previous years.[1] The receipts from diamonds sold, plus the increase of stocks at cost value, amounted to £6,297,782; and the total resources of the company for the year amounted to £7,248,239. Mining expenses were £2,080,622, for depreciations £706,035 was deducted, £235,932 represented interest and sinking-fund charges, and the Mining Profits Tax of the Union of South Africa absorbed £426,465 more. After deducting all these sums there remained £3,799,184, out of which the preference shareholders received dividends amounting to £800,000 and the deferred shareholders dividends of £1,500,000 and a bonus of £250,000. This was 20 per cent. on preference stock and 35 per cent. on deferred stock. To the General Reserve Fund £140,060 was credited. Diamonds unsold, at cost value, constituted a "Suspense Profit" of £595,601. As a result of the liberal dividends (amounting in all to

[1] Report of the DeBeers Consolidated Mines, Ltd., Alphaeus J. Williams, Manager.

£2,255,000), etc., the balance carried forward to next year is £513,521 against £1,042,399 brought forward from the previous year. However, the chairman of the company calls attention to the fact that last year's balance included £471,000 of unsold diamonds, while in this year's statement this item constitutes a special "Suspense Profit," amounting to £595,601, as we have noted; there would thus be an apparent increase of £66,000 over last year.

The average yields of the different mines, as well as the value per carat of the diamonds produced and the value per load of the blue ground extracted were as follows, the data for 1911 and 1912 being added for comparison:

De Beers and Kimberley.	1911.	1912.	1913.
Average yield in carats	0.28	0.31	0.29
Value per carat	51s. 6.29d.	53s. 11.47d.	67s. 3.74d.
Value per load	14s. 5.12d.	16s. 8.716d.	19s. 6.24d.
Wesselton Mine:			
Average yield in carats	0.27	0.29	0.27
Value per carat	37s. 9.6d.	45s. 3.12d.	51s. 2.88d.
Value per load	10s. 2.47d.	13s. 1.504d.	13s. 10.02d.
Bultfontein Mine:			
Average yield in carats	0.38	0.41	0.42
Value per carat	35s. 0.52d.	40s. 8.243d.	45s. 9.29d.
Value per load	13s. 3.79d.	16s. 8.179d.	19s. 2.70d.
Dutoitspan Mine:			
Average yield in carats	0.21	0.23	0.23
Value per carat	73s. 6.5d.	83s. 0.132d.	93s. 0.45d.
Value per load	15s. 5.325d.	19s. 1.11d.	21s. 4.78d.

As will be noted, the yield has remained essentially unchanged, which is a good augury for the future of these mines, especially as the constant progressive increase in the value of diamonds makes the profit greater each year. This will be rendered more apparent by the following data:

DE BEERS AND KIMBERLEY MINES.

	Cost of Production per Load.	Value per Load.	Profit per Load.
1911	8s. 7.67d.	14s. 5.12d.	5s. 9.45d.
1912	13s. 6.78d.	16s. 8.716d.	3s. 1.936d.
1913	11s. 0.67d.	19s. 6.24d.	8s. 5.57d.
WESSELTON MINE.			
1911	4s. 9.09d.	10s. 2.47d.	5s. 5.38d.
1912	4s. 7.576d.	13s. 1.504d.	8s. 5.928d.
1913	4s. 4.45d.	13s. 10.02d.	9s. 5.57d.
BULTFONTEIN MINE.			
1911	3s. 11.45d.	13s. 3.79d.	9s. 4.34d.
1912	3s. 11.357d.	16s. 8.179d.	12s. 8.822d.
1913	4s. 1.28d.	19s. 2.7d.	15s. 1.42d.
DUTOITSPAN MINE.			
1911	4s. 7.09d.	15s. 5.325d.	10s. 10.235d.
1912	3s. 10.665d.	19s. 1.11d.	15s. 2.445d.
1913	4s. 2.09d.	21s. 4.78d.	17s. 2.69d.

The number of loads of blue ground hoisted, the number washed, the total number of carats of diamonds secured, the number of carats per 100 loads, and the selling price per carat for the different mines were as follows:

DE BEERS AND KIMBERLEY MINES.

	Loads of Blue Ground Hoisted.	Loads of Blue Ground Washed.	Carats of Diamonds Found.	Yield per 100 Loads.	Selling Value per Carat.
1911	445,169	1,230,491	350,662 1/2	28	51s. 6.29d.
1912	323,621	378,614	119,013	31	53s. 11.47d.
1913	351,347	419,881	120,514 3/4	29	67s. 3.74d.
		WESSELTON MINE.			
1911	2,422,487	1,423,117	390,192 1/2	27	37s. 9.6d.
1912	2,573,398	2,020,291	581,973 1/2	29	45s. 3.12d.
1913	2,226,157	2,143,232	576,458	27	51s. 2.88d.
		BULTFONTEIN MINE.			
1911	2,457,412	1,866,212	700,398 3/4	38	35s. 0.52d.
1912	2,334,720	2,025,450	834,760 1/2	41	40s. 8.24d.
1913	2,313,477	2,096,378	874,430 1/4	42	45s. 9.29d.
		DUTOITSPAN MINE.			
1911	2,780,070	2,335,240	482,971 1/2	21	73s. 6.5d.
1912	2,718,703	1,845,796	428,213 1/2	23	83s. 0.132d.
1913	2,491,235	2,330,234	540,033	23	93s. 0.45d.
		GRAND TOTALS FOR ALL MINES.			
1911	8,105,138	6,855,060	1,924,225 1/4	.....	.....
1912	7,950,442	6,270,151	1,963,960 1/2	.....	.....
1913	7,382,216	6,989,725	2,111,436	.....	.....

The careful exploitation of these mines is strikingly exemplified by the results of their working, the production of diamond material being fairly constant; indeed the increase in the past year might be accounted for by an expectation of the exceptional demand sure to come from the United States immediately prior to the establishment of the new tariff rates which a changed administration would be almost certain to impose.

The blue ground in sight in the different mines on June 30, 1913, is given as follows:

Mines.	Loads.
De Beers	2,750,000
Kimberley	2,000,000
Wesselton	18,000,000
Bultfontein	12,000,000
Dutoitspan	15,000,000
	49,750,000

Estimating the value of this according to actual working results in each one of these mines the following would be the *profits* to be realized from this blue ground in each mine, deducting cost of hoisting and washing from the selling price, the figures for 1913 being used.

De Beers Kimberley	£1,900,000
Wesselton	8,517,750
Bultfontein	9,071,000
Dutoitspan	12,918,215
	£32,406,965

At $4.87 for the pound sterling this would be $157,810,191.55. It of course only represents a fraction of the potential resources of these mines.

The depths of the various shafts in the mines on June 30, 1913, were:

De Beers:	
Rock shaft	2466 ft.
No. 1 shaft	1670 ft.
Kimberley:	
Main rock shaft	3601 ft.
Atkins shaft	1009 ft.
Wesselton:	
No. 1 main rock shaft	1119 ft.
No. 2 main rock shaft	1425 ft.
Bultfontein:	
No. 1 main rock shaft	1383 ft.
No. 2 main rock shaft	768 ft.

In Wesselton mine, main rock shaft No. 2 was sunk 437 ft. during the year, and the depth of main rock shaft No. 1 in the Bultfontein mine was increased by 383 ft. during the same period; the depths of the other shafts remain as before.

The Premier mine was profitably and actively worked during the year ending October 31, 1913, as appears from the statements in the Eleventh Annual Report issued on that date. The total production of diamonds for this period reached 2,107,983 carats, the greatest quantity ever extracted from this mine in a single year, and an increase of 115,509 carats over the figures for 1912. The higher price of diamonds enabled the company to obtain £2,336,828 for the year's output, being £331,885 more than in 1912. After the deduction of mining expenses, totaling £1,197,597 and of £136,133 for office expenses, etc., there was left a balance of £1,003,098 to be carried to Expenditure and Revenue Account. The sum of £402,806, suspended profit on October 31, 1912, added to this, gave £1,405,904, of which £461,802 represents diamond stock still unrealized, leaving £944,102 immediately available. Of this, £98,079 was assigned to general equipment, and of the balance, £846,023, treated as realized profits, 60 per cent. (£507,614) went to the Government of the Union of South Africa, leaving £338,409 (40 per cent.) as the shareholders' portion.

This sum added to a previous balance of £100,118 and to £78,040 of sundry revenue made £516,567 for the Shareholders' Appropriation Account, out of which £100,000 was paid on the Preferred Stock in two semi-annual dividends of 125 per cent. each, and £300,000 on the Deferred Shares, in two dividends of 350 per cent. and 400 per cent. respectively, or 750 per cent. for the year. The balance to be carried over to the ensuing year was £116,567.

A fairly regular progressive increase in the profit realized on the blue ground taken from the Premier mine during the past 5 years is shown by the following figures, in each case for the year ending October 31:

	Yield in Carats per Load.	Value per Load.	Cost of Production per Load.	Profit per Load.
1909	0.249	3s. 1.43d.	1s. 11.42d.	1s. 2.01d.
1910	0.230	3s. 2.49d.	2s. 0.56d.	1s. 1.93d.
1911	0.213	3s. 5.34d.	2s. 2.02d.	1s. 3.32d.
1912	0.205	4s. 1.57d.	2s. 4.79d.	1s. 8.78d.
1913	0.202	4s. 5.74d.	2s. 6.67d.	1s. 11.07d.

This shows that in spite of a constantly though slowly decreasing yield of diamond material per load, and a slight increase of production cost from year to year, the profit per load is more than nine pence greater in 1913 than it was in 1909, equivalent to over £390,000 on the number of loads washed.

During the past year 10,434,680 loads were washed and, as we have stated, 2,107,983 carats of diamonds were recovered. The 310-ft. level was opened up and worked to some extent, but there is still available above this level approximately 25,000,000 loads of blue ground. Such is the size of this mine that the large amount of material extracted in 1913 deepened it only 31 ft., and the strong quartzite composition of the sides of the mine seems to insure open-cast working for many years to come.

The cost of production will probably be materially reduced in the coming year by the continuous use of the newly installed machine drills and other mechanical appliances. The power needed for the operation of the drills was not available before July, 1913, and the change renders possible a saving of 2000 native laborers. While the average cost of production per load for the year was, as we have seen, 2s. 6.67d., the average cost for the 4 months, July to October, since the new drills have been in operation, is but 2s. 1.54d. Indeed, the Chairman asserts that the trifling increase in cost this year over last year is principally due to the liberal allotment by the company of £85,000 to start a Pension Fund for its employees. Besides this initial gift the company agrees to give £4 for every £1 given by the employees themselves toward the maintenance of the fund.

	No. of Loads Washed.	No. of Carats of Diamonds Found.	Value of Diamonds.
1909	7,517,793	1,872,136 1/2	£1,172,378 7s. 2d.
1910	9,331,882	2,145,832 3/4	1,496,641 5 5
1911	8,325,272	1,774,206	1,433,970 6 9
1912	9,707,098	1,992,474	2,004,943 3 5
1913	10,434,680	2,107,983	2,336,828 15 1
Total	43,316,725	9,892,632 1/4	£8,444,761 17s. 10d.
1903–1908	21,990,251	6,563,071 3/4	6,515,242 13 9
Grand total	65,306,976	16,455,704	£14,960,004 11s. 7d.

The number of loads washed, the number of carats of diamonds recovered and the value of these diamonds are here given for the 5 years (ending October 31) 1909–1913, and from the commencement of work in the mine in 1903:

While the daily average number of loads hauled was 35,462, on a single day, May 19, 1913, as many as 47,098 loads were hauled. The record 6-day week for the year registered the hauling of 242,660 loads; the figures for the record month, July, 1913, passing the million mark by 77,216 loads.

The temporary chairman, Mr. Imroth, in his address to the Board of Directors at the General Meeting held February 13, 1914, in Johannesburg, does not hesitate to express his views very strongly on the advisability, or rather the necessity, of concerted action on the part of all the African diamond interests, if the diamond market is to be consistently sustained and preserved from demoralizing variations in price. He regards the African diamantiferous deposits as "a national asset," and believes that if properly conserved, the world's continually, though perhaps irregularly, increasing demand for this supreme article of luxury will render this asset permanently valuable.

The alluvial diamond deposits of the southwestern Transvaal were profitably worked during 1913, the value of the product for the first 6 months of the year being £278,410 while for the whole of 1911 the output was only £200,000. Although the diggings, taken as a whole, have been so profitable, out of the very large number of individual diggers but a few have been favored by fortune. Areas rich in diamonds occur only here and there, and are often soon exhausted. As a result of the great uncertainties of this kind of mining, a large part of those attracted to this region have been forced to abandon the undertaking, and in several cases those who had been lucky enough to realize satisfactory profits have lost all that they had gained, by investing in new areas which turned out badly; this was more especially the case at Mooifontein, where the richest deposits seem to have been exhausted. Bloemhof, on the other hand, has been more productive, individual diggings in this region having registered a larger output than any others of the southwestern Transvaal. Koppiesvlei Farm, London, and the Eastleigh area follow in point of productivity. The output for June, 1913, will illustrate the relative positions of these areas:

	Carats.	Values.
Bloemhof	1585	£8386
Koppiesvlei	1130 1/4	7176
London	716 1/4	4622
Eastleigh	505 1/4	3611

Other diggings, twenty-nine in number, show returns ranging from 391 1/2 carats of diamonds worth £2479 down to only 1/2 carat worth

£2. The total output for the month was 7252 1/8 carats valued at £43,736. The average carat value of these alluvial diamonds is quite high, being over £6. Bloemhof produced a diamond weighing 32 1/2 carats and valued at £390, a stone of the same weight, valued at £245, was credited to Avondster, and a 24 1/4-carat stone from Panfontein was worth £360. The largest single diamond found came from Koppiesvlei; this weighed 64 1/2 carats and was priced at £430, a very low valuation, indicating that the crystal was not of especially good quality.

The farm Koppiesfontein and a comparatively new district, Schweizer-Reneke, are regarded as very promising; among the first diamonds found in the first-named field was one of 30 carats, and a local syndicate with a capital of £16,000 has been organized for the acquisition of lands in the Schneizer Reneke district.[1]

In the Klerksdorp district of the Transvaal, at De Beers Rush, the finding of a stretch of diamantiferous soil is reported. One stone of 10 1/2 carats has been recovered here and many other smaller ones from 2 1/2 carats down were taken from the wash, which gives good promise of proving profitably workable. Around Bloemhof there are said to be considerable areas of diamond-bearing ground as yet undisturbed.

Two large diamonds have recently been found in the South African alluvial deposits, one of these, of an amber hue and weighing 178 1/2 carats, came from Droegeveld. The finder brought it to London for sale, but not being able to secure his price, he boldly decided to take his chances in having it cut in Amsterdam on his own account. The result is a brilliant of good appearance, weighing 60 carats, the loss in weight being about that usually expected. The other alluvial diamond is somewhat larger; it comes from the Pniel diggings and weighs over 229 carats. The crystal is of octahedral form and is slightly yellowish in hue. The price realized for it was £2300. A considerable influx of diggers to this locality is certain to follow the reception of the news of this lucky find.

A small number of diamonds are exported from British Rhodesia (both southern and northern), the value of these exports for 1911 being $5518, while the figures for 1912, $9981, indicate a considerable increase in quantity, even allowing for the higher price of diamonds.[2]

The diamond industry in German Southwest Africa has been both regulated and stimulated by the reform in the matter of taxation instituted at the end of 1912. Before this time, from 46 1/6 per cent. to 55 11/12 per cent. of the gross value of the diamonds produced was claimed by the Government, and to this must be added a further charge of 5 per cent. by the monopoly controlling the sale of the diamonds. Thus only

[1] *So. Afr. Min. Jour.*, July 26, 1913, pp. 568–570.
[2] *Daily Consular and Trade Reports*, June 28, 1913.

the very productive diamond fields could be worked with any possible chance of profit, as in other cases the expenses of production plus the tax would leave no margin of profit, or might even mean a considerable loss. Indeed, a single diamond-mining company is stated to have closed its operations for 1911 with a deficit, after having paid 1,000,000 marks in taxes. The amended ordinance was passed Dec. 30, 1912, and provides for a tax of 66 per cent. on the gross value of the diamonds *less* 70 per cent. of the cost of production. By this means, the percentage of net profits taken by the Government diminishes in proportion to the relative reduction of these profits, and should the cost of production mount as high as 95 per cent. of the selling price, no tax would be imposed, and the remaining 5 per cent. could at least be regarded as clear profit. As, however, this new measure, while favoring those who work the poorer fields, would operate to raise the impost upon the product of the richer fields, the individual companies have been accorded the privilege of choosing which of the two systems should be applied in any particular case.[1]

Another drawback to more active diamond-mining in the German Protectorate was the exceptional scarcity of labor that prevailed in 1912. From Ovambaland, the chief source of supply, but 2346 laborers could be obtained in that year, while 4232 was the complement required. The long and arduous journey to the mines on the one hand, and especially good harvests in this region on the other hand, were conditions conspiring to reduce the available supply of native workers. To obviate the first-mentioned and persistent obstacle, the Chamber of Mines has proposed the construction of a railway line connecting Otjivarongo with Ovambaland and the occupation and administration of this latter region so as to ensure the maintenance of law and order there. So far, however, the measures taken can only be looked upon as palliatives, and efforts to get laborers from India and China, or from any of the German colonies, have been unsuccessful. Still the situation has been improved to a certain extent by the reduction in taxes, this having made it possible for the mine-owners to pay wages high enough to procure a supply of colored laborers from the Cape.[2]

The diamond monopoly as heretofore existing has been modified by the provision that the mine-owners shall be permitted to buy and hold stock in the monopoly, new shares having been issued for this purpose, thus giving the mining companies a direct voice in the matter of selling their product; it is expected that this will result in the encouragement of competitive buying. At the same time the charge of 5 per cent. formerly

[1] Diplomatic and Consular Reports [British] No. 5141, Annual Series, Germany. London, 1913, p. 11.
[2] *Idem*. p. 12.

imposed has been reduced to 2 per cent. The burden of some of the diamond-miners has also been lightened by a sweeping reduction in the cost of claim licenses from 30 marks to 1 mark 50 pfennigs; this only affecting a few claims south of 26° S. Lat., but covering all claims north of that line.[1]

The introduction of these reforms, or the assurance that they were about to be introduced had an immediate effect on the local diamond-producing industry, the production for September, 1912, being 102,600 carats, while before this date the average figures were from 60,000 to 70,000 carats per month; this higher level has been since maintained. Part at least of the rapid and notable increase in September, 1912, was due to the regular working of the Pomona mine, where the settlement of a dispute as to the ownership of the fields inaugurated a period of active exploitation. It is in the vicinity of Pomona that the largest German diamonds have been found, the largest stone that has been met with up to date in these fields being a crystal weighing between 33 and 34 carats found just beyond the Pomona boundary. This stone, which is of excellent color, appears to be part of a larger crystal.[2] The following figures give the annual production of these fields and the value of the product in marks.[3]

	Carats.	Value in Marks.
1908	39,375	51,180
1909	483,268	15,435,522
1910	867,296	26,860,074
1911	747,152	23,034,148
1912 (9 mos.)	629,130	19,399,000
(3 mos. approx.)	363,250	

This would give a total of about 1,000,000 carats for 1912. The most accurate and definite figures are those furnished in the reports of the diamond monopoly ("Diamant Regie"). According to the report for the year ending Feb. 28, 1913, the weight of diamonds sold by the monopoly was 902,157 carats against 816,296 in the previous year, the amount realized being 26,490,000 marks; the corresponding figures for the year 1911–1912 were 20,898,000 marks. At the same time there was an increase in the carat value of the material from 25 marks 6 pf. in 1911–1912 to 29 marks 3 pf. in 1912–1913. The increase in the average size of the diamonds was a main factor in producing the higher price, and was due to the generally larger size of the diamonds from the Pomona district.

Recent investigations have shown that the depth of the diamantiferous gravel is much greater at some points than was heretofore believed, and in soft calcareous stone deposited in the gneiss bed-rock a few diamonds have been found. In some cases the diamond-bearing gravel is

[1] Diplomatic and Consular Reports [British] No. 5141, Annual Series, Germany, London, 1913, pp. 12, 13.
[2] *Idem*, p. 15.
[3] *Idem*., p. 14.

buried beneath a superincumbent layer of gravel not containing diamond material, and the profitable working of such areas is something of a problem under present conditions. The hoped-for discoveries in the Gibeon district have not been realized.[1]

The Colonial Mining Co., Ltd., operates over a territory having a total area of 7305 hectares, divided into a northern and a southern complex. In 1913, 1721 persons were employed by the company (163 whites and 1558 African natives), in their own immediate fields and in those of the Diamant-Pacht-Gesellschaft, a company which secured a lease of the German fiscal diamond claims. In 1913, the Colonial Co. took from all their fields 450,827 carats of diamonds. In 1912, the production was somewhat greater, amounting to 527,223 carats, which sold for 14,610,360 marks, and gave, after deducting working expenses, taxes and export dues, net profits of 4,382,493 marks, of which sum 428,953 marks goes to the credit of the Diamant-Pacht-Gesellschaft.[2]

Another important company the Colmanskop Diamond Mines, Ltd., is an English corporation, having its seat in Capetown. This was the first company in this region to install machinery in all parts of its field, thus ensuring a more systematic and productive exploitation. In 1914 the exclusive employment of electricity as the motive power is contemplated, so as to fully utilize the already existing electrical plant. The production here for 1913 was 106,878 3/4 carats, as compared with 122,525 carats in 1912, and 147,234 3/4 carats in 1911, the considerable decrease in 1913 being due in great part to the difficulty experienced in obtaining the services of native laborers. Still, owing to the higher price of diamonds, the financial returns were not reduced. The dividends paid by this company on its shares have fluctuated notably since its foundation, the exact figures being as follows: 1909, 55 per cent., 1910, 45 per cent.; 1911, 22.5 per cent.; 1912, 30 per cent.; 1913, 30 per cent. For 1914, the company's activity is seriously menaced by the smallness of the share of the officially restricted output that has been allotted to it, so that the director does not express himself very confidently as to the operations here for the present.[3]

The German Diamond Co., Ltd., controls 35,694 hectares. The company has systematically pursued investigations as to the origin of the diamonds, and although it has not been possible to attain definite results in this research, the investigation has contributed much valuable information to the study of the matter. The diamond production of this company, since operations began in 1909, is as follows:

[1] Diplomatic and Consular Reports [British] No. 5141, Annual Series, Germany, London, 1913, p. 15.
[2] "Die deutschen Diamanten und ihre Gewinnung," eine Erinnerungsschrift zur Landesausstellung Windhuk, 1914, pp. 42–48.
[3] *Ibid.*, pp. 49–57.

Years.	Carats of Diamonds.
1909	69,207
1910	135,038
1911	130,291
1912	158,158
1913	172,710
Total	665,404

The number of workers has steadily increased, from 233 in 1909 to 1209 in 1913 (92 whites and 1117 African natives).

While the amount realized for the diamond output of the company was considerable, so large a share was absorbed by working expenses and taxes, etc., that the net results were not very satisfactory:

	Gross Returns in Marks.	Net Returns in Marks.
1909	2,779,283	456,405
1910	4,278,770	115,837
1911	3,936,350	−112,387[1]
1912	5,045,664	648,675
Total	16,040,067	1,108,530

From this total of net returns must further be deducted the sum of 114,077 marks, constituting an additional impost provided in an agreement of May 7, 1910. Thus the actual net returns for the 4 years 1909–1912, really amounted to a trifle less than a million marks, or only 6 1/4 per cent. of the gross receipts for the period in question.[2]

The second year's business of the Pomona Co. has been quite satisfactory. Of 617,038 carats of diamonds produced, 512,383 carats have been disposed of, realizing $6,770,775; after deducting taxes and expenses, $4,795,600 remains for net profits. The selling price, $13.20 per carat, as compared with $10.50 per carat for the previous year, makes a good showing, due in part to the higher value of diamonds and in part to the larger average size of the stones, this having been 23/64 carat in 1913 against 18/64 carat in 1912. Of the total product 104,872 carats remain unsold and will be credited in the next statement at cost price. It is expected that a dividend of 175 per cent. will be declared by the company on the year's business, although the expenses were increased by $1,125,000 because of the higher net tax. Probably the current year will not make as favorable a showing, as the enforced reduction in sales cannot be offset by a corresponding decrease in expenses.

The last assignment of German Southwest African diamonds was made to the London Diamond Syndicate, instead of to the Antwerp Syndicate which has handled these diamonds heretofore. This action signalizes an important change in the policy of the German Diamond Regie, and carries out the now prevailing desire to insure such a control of the diamond market, more especially in the case of the smaller stones,

[1] Deficit.
[2] "Die deutschen Diamanten und ihre Gewinnung;" eine Erinnerungsschrift zur Landesausstellung Windhuk, 1914, pp. 70–77.

that prices will be steadied and competition of an undesirable kind eliminated as far as possible. All who are familiar with the normal course of business know that while competition within certain reasonable limits is rather to be invited than avoided, any competition arising from inability or unwillingness to retain a product until it can be absorbed by a normal demand is certain to cause temporary, and perhaps even to occasion permanent injury to the trade in the commodity in question.

The accumulative sales of diamonds taken from the shores of German Southwest Africa for 1913 amounted to 900,000 carats and brought in $5,000,000.

The German Colonial Office has decreed a notable restriction of the Southwest African diamond output, cutting this down by about one-third. For 1914, the production is to be limited to 1,038,000 carats, apportioned as follows among the different companies:

Company.	Carats.
Colonial Mining Pomona	350,000
Colonial Mining Co., Ltd	245,000
Diamond Lease Co	109,000
German Diamond Co., Ltd	118,500
Kolmanskop	89,500
United Diamond Mines, Lüderitsbucht	50,000
Weiss de Meillon	18,500
Various smaller companies	57,500
	1,038,000

This course is to be followed in succeeding years, the permissible production being determined each year according to the generally prevailing market conditions. To each company is given the privilege of partially or entirely transferring its right of production to any other company, the essential point with the German administration being a curtailment and regulation of the total output, its distribution among the different mining concerns being a matter of indifference.[1]

In a recently published study of the geological conditions of the Lüderitzbucht diamond fields, Dr. H. Lotz, after passing in review various theories that have been advanced to explain their source, finds himself obliged to confess that the problem is still unsolved. The fact that the diamonds here are almost always associated with agate pebbles is taken to indicate a common origin. They both frequently occur in marine deposits of Tertiary age, on extensive terraces not far above sea-level. In this connection it may be mentioned that careful observations have revealed that the entire coast is gradually rising. The theory formerly maintained, that the diamonds came from cretaceous sediments, is regarded as lacking sufficient proof; the fossils belong to the Miocene period.[2]

[1] *The Jewelers' Circular Weekly*, Jan. 21, 1914, p. 57.

[2] H. Lotz, J. Böhm and W. Weissermel, "Geologische und paläontologische Beiträge zur Kenntniss der Lüderitzbuchter Diamantablagerungen," *Beiträge zur geologischen Erforschung der deutschen Schutzgebiete*, Part V, Berlin, 1913.

A productive and promising diamond field is now being worked in the Belgian Congo, by the "Société Internationale Forestière et Minière du Congo," a Belgian-American corporation in which Thomas F. Ryan and Guggenheim Bros. are prominently interested. To this company has been accorded the right to work a large alluvial diamond field in the southwestern part of the Belgian Congo, this field embracing the middle reaches of the Kassai river, and its chief western affluents including the Tshikapa and the Longatchimo. Diamonds were already discovered here in 1907, but effective prospecting was hindered by the hostile attitude of some of the native tribes of the region. In 1911, however, prospecting was resumed, and by June, 1913, active mining work was in progress, though only rude mechanical appliances were used. Nevertheless, during the last 6 months of 1913 about 15,000 carats of diamonds were obtained, and it is confidently expected that the returns for 1914 will be considerably greater. Although the stones are generally quite small, averaging scarcely more than 1/10 carat in weight, they are of excellent quality; the largest so far found weighs 15 carats.

Up to the present time mining operations have been confined to the gravels of small streams or to so-called "pay channels" in terraces along the larger rivers, but ancient and elevated terraces are also known to be diamantiferous, and presumably also a conglomerate horizon in the Jura Triassic sandstones, which in this country overlie unconformably certain supposed pre-Columbian schists and granitoid rocks. The discovery and partial exploitation of some pipes, apparently of kimberlite, is reported from the Katanga region. A few diamonds have been obtained in this way as well as from alluvial deposits in two other localities in the Katanga. Three or more of the gold placers in the northwestern part of the Congo have also yielded diamonds.[1]

The first public sale of Congo diamonds was held in Brussels at the beginning of this year (1914). As many as thirty firms of dealers were represented. Diamonds from the Kassai to the weight of 6795 carats were offered and this entire consignment, the property of the Société Internationale Forestière et Minière du Congo, was acquired by a single purchaser for the sum of 203,985 francs, equivalent to 30 francs per carat.

The extent of the territory in the Belgian Congo controlled by the Belgian-American Co. is very considerable, embracing 10,570 square miles. In addition to diamonds, gold, platinum, silver, copper, iron, petroleum, bitumen and sulphur are to be found here. The services of fifteen American engineers and prospectors are being utilized for the dia-

[1] This information in regard to Congo diamonds has been courteously communicated to the writer by Dr. S. N. Ball.

mond mining and development, and the eventual success of the undertaking will be much favored if the Belgian Government intends to waive its right to control the exportation and sale of the diamonds as has been reported. In view of the likelihood that similar deposits are to be met with across the Portuguese frontier in Angola, an affiliated company has been founded in Lisbon, with a capital of $289,500. This Portuguese branch company is called the "Companhia de Pesquisas Mineiras em Angola."[1]

The discovery of diamonds in the gravels of Mutendele creek in 1907 and, some 95 miles away, of "pipes" of kimberlite traversing the Kundulungu (Permo-carboniferous) red sandstone, was made through the efforts of the Kundulungu-Luabala Co., organized for diamond prospecting in the Katanga region of the Belgian Congo. The largest of the "pipes," that at Luanza, was tested to a small extent in 1912, and stones said to equal in quality those of the German Southwest African deposits were obtained. These kimberlite pipes are asserted to be quite similar to those of South Africa. That at Luanza is of elliptical form, measuring 300 meters and 500 meters along its minor and major axis respectively. Pits sunk here, after passing through from 3 to 6 1/2 ft. of clay with quartz pebbles, and from 6 to 20 ft. of detrital or alluvial clay, encounter a "yellow ground," consisting of chromite, amphibole, olivine, garnet (almandine or spessartine), and quartz. It has been suggested that the amphibole (not present at Kimberley) may be an erroneous determination of a pyroxene (omphacite). Only a much more consecutive and extensive exploitation than has as yet been even attempted will show whether these kimberlite formations contain diamonds in sufficient quantity to make mining operations financially successful. Alluvial deposits, a few of which yield enough diamonds to make fair returns to the diggers, are to be found in the southwestern part of the Belgian Congo.[2]

Asia.—In India, diamond mining has long been practically abandoned, although now and again the incidental finding of a fine stone is reported. Recent statistical returns published by the Government of India give the total annual diamond output as only 150 carats. An attempt was made some 20 years ago to open up the old Parteal mine, whence the famous Regent Diamond is said to have come. The operations were conducted by the Deccan Mining Co., a corporation to which the Nizam of Hyderabad accorded a concession covering all mining operations in his territory. Machinery of the South African type was installed and work was carried on more or less actively for 10 years, the old diggings being

[1] Ross J. Haseltine, *Daily Consular and Trade Reports*, October 8, 1913, p. 159.
[2] "Discovery of Diamonds," *Mining and Science*, April 19, 1913.

favored, as they were found to be more remunerative than new ones experimentally tested here and there. The enterprise was not substantially successful and the work was finally abandoned, the machinery being taken away.[1]

Australia.—The Copeton diamond workings in Australia are said to be carried on quite actively at present, a result favored by the increased value of diamonds and also by the profit realizable from a sale of the tin oxide inclusions in the diamantiferous deposits. The statement has been made that these Australian diamonds, which closely resemble those from Brazil, are to a considerable extent sold as products of that country.[2]

The largest gem diamond from the Copeton field is stated to have weighed over 6 carats; as a rule, however, the diamonds are small, averaging perhaps three to the carat. From the detritus of the Round Mount mine, 120 diamonds are said to have been taken in a single week toward the end of 1913. These were sold at the rate of 22s. 6d. per carat, a price indicating that the stones were of good average quality.[3]

A test of the value of the diamond wash in the Alfredomia mine, one of those in the Copeton district, Australia, was recently made by a representative of the Australische Diamant Syndicaat of Amsterdam and Antwerp. From 200 loads of wash-dirt that were treated in a rotary puddling-machine, diamonds to the number of 770 were secured, their total weight being 177 carats. Here, as elsewhere in these Copeton fields, the tin oxide recoverable from the alluvial detritus constitutes a considerable addition to the profits of the operations.[4]

Europe.—The discovery of microscopic diamonds in France has recently been reported. They are said to have been found in a deposit of "blue-ground" resembling that of South Africa, this appearing in the midst of decomposed graphitic schists. The locality is between Bellac (Haute-Vienne) and Confolens (Charente).[5]

North America.—The first really effective attempt to work one of the diamond areas of Arkansas was made in 1913, when the Ozark Mining Co., which had put up a first-class washing plant with a capacity of 100 loads for a 10-hr. day, was operated for about 3 months in washing kimberlite from the first "pipe" discovered in this region. Some 5000 loads are said to have been washed, but unfortunately no definite report as to the number and weight of the diamonds recovered is accessible. Seven or eight hundred stones are said to have been found; it is readily apparent that if the average weight was a half-carat, or

[1] Charles S. Grossman, "Golconda and the Golconda Mines," *Jewelers' Circular Weekly*, March 11, 1914, pp. 59, 61.
[2] *Austral. Min. Stand.*, Dec. 3, 1913. *Eng. Min. Jour.*, Feb 14, 1914, p. 381.
[3] *Austral. Min. Stand.*, Dec. 4, 1913.
[4] *Austral. Min. Stand.*, Feb. 6, 1913.
[5] *Echo des Mines.*

perhaps even as low as a quarter-carat, the returns per load washed would be very small. The excavations made in bringing out the material rendered it possible to form the opinion that the kimberlite is deeper than was supposed at the outset. The Kimberlite Diamond Mining and Washing Co. has erected a small plant on Prairie creek, and has made tests of its capacity; eventually it will treat from 50 to 100 loads per day. While no work is reported as having been done by the Arkansas Diamond Co. during 1913, greater activity is looked for in 1914 as a result of a reorganization of this company. To facilitate the distribution of its expected products, the Kimberlite Diamond Mining and Washing Co. has built a mile of tram line from the mine to the mill.[1]

An occurrence of microscopic diamonds in Ontario, in connection with chrome iron ore, in a basic, peridotitic rock, weathering easily to serpentine, and closely resembling that whence came the similar diamonds from Olivine Mountain, British Columbia, has been recently reported by Dr. W. G. Miller, Provincial Geologist of Ontario. A sample from Reaume township, about 20 miles north of Porcupine Lake, was submitted by him for examination to Mr. R. A. A. Johnston of the Geological Survey, Ottawa, and numerous very minute microscopical diamonds were found therein. The existence of diamonds in Ontario has long been postulated, from the apparently good evidence furnished by a few that have been found in the glacial drift of Wisconsin; unfortunately, however, the exceedingly minute particles now discovered, though undoubtedly diamonds, have absolutely no commercial value, and do not afford any indication of the presence of larger crystals. Hence, while very interesting from a purely scientific viewpoint, we still have to wait for a discovery of valuable diamonds here or elsewhere in Canada.

South America.—If the project of the Governor of British Guiana, Sir Walter Egerton, for the construction of a railroad line extending from the coast to the Brazilian frontier, a distance of some 340 miles, should be successfully carried out, the diamond resources of this region will undoubtedly be much more effectively exploited than has heretofore been the case. As noted in our last report,[2] the total production of diamonds in British Guiana from April 1, 1900 to June 30, 1912 was 1,006,557 stones having a total weight of 74,203 carats (76,170 metric carats), giving an average of less than 0.08 of a metric carat for each diamond. Thus the stones recovered are prevailingly small; nevertheless the fact that the diamond exports for the year 1911–1912 were valued at $56,505, may be taken to indicate that under improved conditions this field would become a good producer.

[1] John T. Fuller, "The Arkansas Diamond Field in 1913." *Eng. Min. Jour.*, Sept. 13, 1913.
[2] MINERAL INDUSTRY, Vol. XXI, 1913.

A diamond occurrence in Brazil, bearing a striking resemblance to those of South Africa, is presented by the Agua Suja diamond diggings in the upper reaches of the Bagagem valley, State of Minas Geraes. Here the conditions have been considered to indicate that we have to do with a local deposit, not with washings from distant points as in the greater number of the Brazilian diamond occurrences. While granite and schist constitute the rock of the surrounding country, the diamantiferous bed is here composed of a bouldery conglomerate, containing over 90 per cent. of basic igneous rocks, locally found intrusive in the granitic formations, the diamonds appearing in the greasy red clay cementing the boulders, this clay also containing pyrope garnet and perofskite in considerable quantity, some limonite and a little olivine. As the action of fluvial forces seems to be excluded in this small valley 400 ft. higher than the Bagagem river, the diamantiferous material is believed to have resulted from eruptive disintegration of basic igneous rocks, and the consequent intrusion of the diamonds and their associated minerals into the cementing substance. Hydrothermal action is believed to have been the determining cause of these deposits, which offer the closest analogy to the South African occurrence of diamonds in connection with a kimberlite pipe that has so far been noted in Brazil.[1]

From Brazil have come reports of a rather indefinite character to the effect that a revival of diamond exploitation there is about to be realized. The Paraguassa region is said to be the scene of considerable activity on the part of certain interests, the preliminary operations involving modification of river courses, draining of jungles and the planning or construction of hydraulic works. The stagnation of the diamond-mining industry in Brazil is attributed, in part at least, to the unduly high taxes imposed by the Government, and some relaxation in this respect is hoped for. Another drawback has been the somewhat lessening demand for carbonado, the form of diamond that has been chiefly exported from Brazil of recent years. A cause for this has been found in the increased utilization of improved steel for the equipment of drills for work where formerly carbonado was the material almost exclusively used.

Amber

The amber from the Palmnicken[2] deposits near Königsberg in east Prussia is found in a "blue ground" having in places a thickness of 7 meters. These deposits constitute the main source of the amber of

[1] David Draper, "Analogies between the diamond deposits of Brazil and South Africa," *Min. Mag.*, Dec., 1913, pp. 435, 436.

[2] Extraccion y preparacion del ambar amarillo en Palmnicken (Prusia); *Revista Minera*, Nov. 16, 1913, p. 552.

commerce. The extraction is essentially a state monopoly, as a special authorization is requisite for the operation, although the state is not empowered to pursue mining operations on its own account without the consent of the proprietors of the field. The greater part of the material comes from the "Royal Amber Works" mine "Anna," situated some hundred meters from the Baltic coast. As the excavations are shallow, not exceeding 25 meters in depth, the "blue ground" can be taken out quite rapidly. The amber-contents of a cubic meter of the ground ranges from 10 to 18 kg. The ground on extraction is dumped from the cars into are ceptacle holding 150 cubic meters, the bottom having perforations through which the smaller particles can pass, only retaining the larger pieces of amber. The material is then successively passed through finer sieves so as to secure a graded series of the amber particles. The larger pieces of amber are washed for 10 hours with water and sand to remove adherent substances. The fragments of good quality measuring from 1 mm. to 12 mm. are utilized for the manufacture of pressed amber, and the poorer material is distilled to secure amber varnish, by-products being oil of amber and succinic acid. The industry gives employment to 1000 workers, male and female, in the mines, etc., and to 500 additional workers occupied in their homes in Königsberg and Palmnicken. The miners get about $1.25 per day, the average wages for all being, however, only about 80 cents a day.

Sales for 1911 are reported as follows:

	Kilograms.	Average price per Kilogram.
Raw amber	66,700	$5.77
Pressed amber	23,500	22.17
Colofonia	158,200	0.37
Acid	1,300	3.80
Oil	31,700	0.047

Various explanations have been offered to account for the progressive diminution in the amount of amber obtainable from the "blue ground." The average amber yield of a cartload of this soil has decreased from 739 grm. in 1900 to only 492 grm. in 1911, and mining operations covering 1 hectare of ground produced in 1900, 111,283 grm., while in 1911 the same area yielded but 73,430 grm. In some instances the supply is believed to have been diminished by the modified action of currents, another general cause being found in the gradual levelling of the coast so that the single pieces of amber are not so readily landed by the waves as was formerly the case.[1]

That the amber deposits of east Prussia are older than the "blue ground" in which they are found, is the opinion expressed by Dr. F.

[1] *Jewelers' Circular Weekly*, March 4, 1914, p. 51.

Kaunhowen; the "blue ground" is assigned by him to the lower Oligocene age.[1]

Some good specimens of amber have been collected by fishermen on the Sicilian coast near the city of Catania. This material is believed to have originated ages ago from the hardened gum of trees along the banks of the Simeto river. The river carried down the gum to the sea and during and after stormy weather the amber is cast up on the beach. Some pieces of this amber show very interesting and pretty inclusions of insects, plant growths, etc.[2]

Emerald

Australian opals have for some time past been favored gems, and now there seems to be a possibility that a supply of fine emeralds may be provided by this flourishing British Colony. As has often been the case with gem-stones, the first emeralds here were found by prospectors in search of deposits of metal, the discovery having been made in 1909 at Poonah, in the Murchison gold field, in western Australia. These emeralds occur along a creek not far from some alluvial tin workings, where the stream had cut its way through a ridge of greenstone, and the green beryls were to be found scattered on the surface of this ridge. Most of the crystals are rather small, the largest reported being about an inch long and a half inch thick; they are evidently not *in situ* but the parent rock is thought to be not very far distant, judging from the comparative perfection of the crystalline faces. The prevailing opinion sees their source in the underlying mica schist, from which they are believed to have been first freed by weathering and then carried off by the action of rain and wind.[3]

The annual exploitation tax on the Emerald Mines of Colombia, amounting to $60,000, has been changed to an impost of 10 per cent. on the gross sales of the emeralds extracted.[4]

Garnet

A new bed of fine garnets of a dark puce color was found about 1906 in Ceylon, at Pellawella, in the Southern Province. A more important new discovery of precious stone material on this island is that of a deposit of exceedingly fine moonstones, having a blue and white sheen. This is a great piece of good fortune for the Ceylonese trade in this beautiful

[1] F. Kaunhowen, "Der Bernstein in Ostpreussen," *Jahrb. Kgl. Preuss. Geolog. Landesanstall*, XXXIV, Pt. II, Heft 1, pp. 1–80 (1913).
[2] Communicated by Robert Yates Barkley, American Vice Consul (in charge), Catania, Italy.
[3] *Min. Jour.*, March 29, 1913, p. 304.
[4] *Bulletin of the Pan-American Union*, XXXVI, 456 (1913).

gem, as the older mines at Kandy and Wagawella are almost worked out. These Ceylonese moonstones are cut and polished at the great gem-cutting works at Idar, Germany.[1]

See also GARNET in the chapter on ABRASIVES.

JADE

The Burmese jadeite mines at Seik-moo and Hweka are said to have been worked with interruptions from 1790 to the present time, the Burmese Government having established a station for the handling of this product at Mogok in 1806. At one time, between 1831 and 1840, as many as 1400 workers are said to have been employed, and although the industry has suffered many setbacks since then, the establishment of the British protectorate in 1889 has given it a firmer basis.[2]

An enormous block of New Zealand jade (*punamu*, or "greenstone") said to weigh as much as 2 tons and measuring 7 ft. in length, 4 ft. in width and 3 ft. in height, has been transported to Germany via Sydney, Australia. The quarry of the New Zealand Greenstone Co., at Greymouth, New Zealand, is the source of this exceptionally large mass of jade, which has been valued at £700.

LAPIS-LAZULI

Deposits of lapis-lazuli are so rare in the United States that the discovery of this mineral in San Antonio Cañon, southern California, some twenty miles south of San Bernardino, is of interest, although the material to be collected is unfortunately of poor quality. Some years ago the existence of a blue rock was noted here, and tests made of specimens by John T. Reed, a chemist and assayer of San Bernardino, determined the presence of lapis-lazuli. More recently Prof. Lauterbach of the University of California and R. M. Wilke, a mineralogist of Palo Alto, Cal., while visiting San Antonio Cañon, picked up specimens of the blue rock. Toward the end of 1913 a systematic search for this deposit was instituted by Mr. Gordon Surr and two of his friends, but they were not successful in finding lapis-lazuli *in situ*, although loose pieces were collected from a stream bed in the immediate neighborhood of the spot which had been tested several years before. As we have noted, the material is of poor quality, and is described as being apparently "a dark-gray quartzite streaked with parallel, pale to deep blue bands, from an eighth to over half an inch wide; the blue material and the other parts of the rock show abundant fine grains of pyrite."[3]

[1] C. K. Moser, *Daily Consular and Trade Reports*, Aug. 14, 1913, p. 822.
[2] Maxwell K. Moorhead, *Daily Consular and Trade Reports*, May 13, 1914, pp. 845, 846.
[3] Gordon Surr, "Lapis-lasuli in Southern California," *Min. Eng. World*, Dec. 27, 1913, pp. 1153, 1154.

Opal

A discovery of opal is reported from New Mexico. The deposit is situated about 12 miles to the eastward of Silver City, and is near the station Bayard on the Santa Rita branch of the Sante Fé Railroad. The opal supply has been obtained at slight depths or from the surface, and while the stones so far secured are of good quality, the belief is expressed that at greater depths finer material will be met with. The 25-ft. shaft that has been sunk traverses talc. The local conditions as to water supply, wood, etc., are good; opals from this source have been cut and mounted in Los Angeles, Cal.

Pearls

Pearls constituted 87 per cent. of the exports for 1911–1912 from the Bahrein Islands, but many of these had already been imported from the other fishing-banks of the Persian Gulf and were re-exported from Bahrein, which has largely taken the place formerly occupied by Bombay as a center of the pearl trade. There is stated to have been a recent local rise of from 30 to 40 per cent. in the price of pearls at Bahrein, and the assertion is also made that they now bring there nearly ten times the price that could be obtained for them 20 years ago. The value of the pearls sold finally in Bahrein in 1911–1912 and exported by the purchasers has been placed at 15,000,000 rupees ($4,875,000), the share of European merchants being some 4,000,000 rupees ($1,300,000), the remainder having been acquired by Arabs and Hindus for future re-sale in Bombay. This represented about half the value of the total exports, the other half being sent by local Arab dealers directly to Bombay for sale there. Representatives of a French firm, of a London firm and of a Bombay firm are stated to have operated in Bahrein during the year.[1]

The value of the imports of pearls to the Bahrein Islands from various countries during the years 1099-1910, 1910–1911, 1911–1912 were as follows. Rupees reduced to dollars (1 rupee = 32.5 cents).

Country.	1909–1910.	1910–1911.	1911–1912.
Turkish Austria	$162,500	$443,625	$1,300,000
Koweit	487,500	765,125	1,300,000
Katar	1,365,000	297,375	975,000
Persia	32,500	60,125	97,500
India	.....	97,500	59,637
Trucial Oman	.....	268,125	650,000
Total	$2,047,500	$1,931,875	$4,382,137

[1] Diplomatic and Consular Reports [British], No. 5052 Annual Series, Persian Gulf, London, 1913, p. 14.

The value of the exports for the same period and the countries of destination were:

Country.	1909–1910.	1910–1911.	1911–1912.
India	$2,271,750	$4,450,875	$9,724,000
Persia	.....	23,725	.....
France	.....	52,000	.....
Total	$2,271,750	$4,526,600	$9,724,000

Pearls of considerable value continue to be found from time to time in the Australian pearl-fisheries, and although the fortunate diver often fails to get any just proportion of the true value of his pearl, he sometimes realizes a sum that means much to him. As an extreme instance of the unjust advantage taken of the diver by shrewd bargain-hunters, may be noted the case of a West Australian pearl which eventually sold for £10,000, but for which the original finder only received £10. However, not many of the Australian pearls are worth more than from £700 to £1,000.

The attempt to employ white divers for pearling on the Australian coast seems to have conclusively shown that they are unable to compete with Asiatics either in cheapness or efficiency. While an Asiatic is satisfied with wages of from $10 to $15 a month, to which is added a commission on the amount of shell raised, a white man will expect $70 a month, plus a similar commission, although the Asiatic will bring up between 4 and 5 tons' weight of shell in a year and the white man not more than a single ton in the same period. To this must be added the great difference in the cost of subsistence, this being three times as great for the white man as it is for the Asiatic. Moreover white men appear to be physically incapable of sustaining the shocks and strain of continuously repeated divings.

Persistant and successful efforts have been made to increase the numbers of the pearly fresh-water mussels whose shells supply the material for our very extensive button-making industry. The occasional finding of fresh-water gem-pearls in these mussels is a windfall thankfully welcomed by the lucky finder, but their chief and permanent value is for the industry in question. The well-equipped Government fish-culture station at Fairport, Iowa, has been a center of activity in this direction, field parties sent from there having operated locally at fifteen different places in the Mississippi valley, ten of these being on the Mississippi river. The work covered points in Iowa, Minnesota, Wisconsin, Illinois, Indiana and Arkansas. In all 150,000,000 young mussels were placed, 57,000,000 being placed in Lake Pepin and 25,000,000

in the vicinity of Freeport. An extension of these operations to points on the Illinois river and to many lakes and streams in Minnesota, thus opening up new sources of supply for the button-making industry, has been suggested by an investigation of the conditions in those localities.[1]

The course of business during 1913 in the pearl-market was essentially the same as in the diamond-market, the activity of the greater part of the year being followed by a decided reaction toward its close. This comparative depression continued through January, 1914, but since then there has been a healthy recovery, due to the constant demand for pearls and to the gradual depletion of stocks. Paris houses note an active demand from Austria, Germany and Russia. There has been no decline in price from the high figures that have ruled for some time.

SAPPHIRE

The Amakie sapphire deposits of Queensland, Australia, are of considerable extent, covering an area of some 30 square miles.[2] The "wash" in which the sapphire material is usually found is sometimes superficial, as in the valley bottom of the Black Soil claim, while in other places it is covered by an overburden of several feet, in which, however, gem-material is occasionally present. The sapphires are as a rule of low grade but sometimes large stones of fair quality are brought to light; two weighing 128 metric carats and 218 metric carats respectively have been found west of the Grave Hill washings. The Queensland claim alone has produced $43,000 worth of sapphire in the past 3 years; here the "wash" is 5 ft. thick and the average yield per load is 4 oz. of "blues." In the Renard claim, the richest in these fields, dark violet stones of large size have been found, ranging in weight up to 3 oz.; "fancy stones" of good size came from the Iguana Flat claim. Improved washing processes have been introduced of late years, rotary machines being used for sifting out the gem material. The total value of the production for 1912 was $192,000; the price is determined essentially by the German demand, the stones being cut in the German gem-cutting works and most of them sold in various parts of Russia. Average prices for the rough material have been quoted as follows:

"Fancy stones"	$25 to $480	per ounce
Largest "blues"	$28.80	per ounce
Large "blues"	$12 to $16.80	per ounce
"Parcel blues"	$8.40	per ounce
Small "blues"	$1.80	per ounce
Machine stones	$0.75 to $0.80	per ounce

[1] Annual Report, Commissioner of Fisheries, 1913; Washington, 1914, p. 28.
[2] Lionel C. Ball, "The Amakie Sapphire Fields of Queensland," *Min. Sci. Pr.*, July 26, 1913, pp. 151, 152; abstract from *Queensl. Min. Jour.*

Tourmaline

On the Syssert mining property, south of Ekaterinburg, in the southern Urals, a tourmaline deposit has been discovered presenting some unusual conditions. The rock here, on the boundary of the European and Asiatic watersheds, is preponderantly of granites and serpentines. It is in a serpentine, and not far removed from its point of contact with a calcareous rock of the Lower Devonian period that the tourmaline has been found. The specimens are optically negative, and show an intense dichroism, dark brownish green and pale brownish yellow. The presence of tourmaline in a serpentine, close to its immediate contact with a calcareous formation, is very significant. It shows that the magma producing the basic rocks whence the serpentine is derived, must be accompanied by mineralizers analogous to those so abundantly present in the acid rocks, and it is held that these tourmalines were formed by the fumaroles of the mineralizers.[1]

Turquoise

Much valuable information regarding the present use of turquoise in the Orient and the commerce in this very attractive stone in certain eastern lands is given in a recently published monograph on the turquoise by Dr. Berthold Laufer.[2] In it all that can be gathered from ancient, medieval and modern records as to the history of the gem is very fully presented. Of the modern eastern trade in this stone, that of China radiates from two principal distributing centers, Mongolia deriving its supply from Peking, while Tibet, a country in which turquoise is a great favorite, is supplied from Si-ngan, where some half-dozen traders, settled in the same street, work up the raw material into beads and perforated flat stones. As a rule the turquoise material in Si-ngan is sold by weight, a catty, about 1 1/3 lb., bringing from $3.50 to $5.60, but very finely polished beads, or specimens of superior quality, are priced by themselves, having what is termed a "fancy value."[3]

[1] L. Duparc and H. Sigg, "Sur un gisement de tourmaline dans un serpentine de l'Oural," *Bull. Soc. Franc. de Mineral.*, XXXVII, 14–19 (1914).
[2] Berthold Laufer, "Notes on Turquoise in the East," Field Museum of Natural History, Publication 169, Anthropological Series, Vol. XIII, No. 1, Chicago, July, 1913.
[3] *Op. cit.*, p. 63.

QUICKSILVER

By Clifford G. Dennis

In the United States the production of quicksilver during 1913 decreased 5383 flasks of 75 lb. each, valued at $279,887 below that for 1912. This is the lowest production of the metal reported since 1860 and

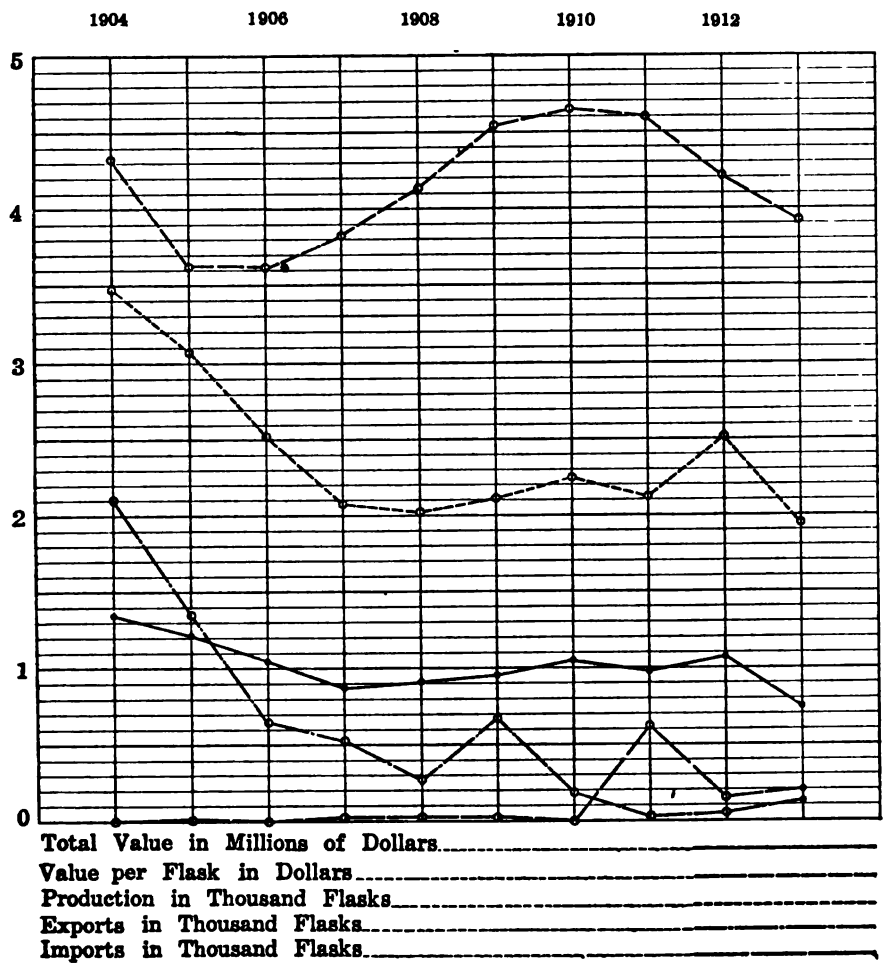


Fig. 1.—Statistics of Quicksilver for Ten Years.

is due primarily to bad market conditions and secondly to decrease in metal tenor of the ore at two of the principal mines in California. Several mines in Sanoma, Lake, and San Bonita Counties, California, would

undoubtedly have increased their production had the market condition been more favorable. The same may be said of several properties in the state of Nevada where properties are sufficiently developed for reduction equipment but are awaiting more favorable market conditions before tieing up their capital.

The total production for the United States for the year 1913 was 19,681 flasks valued at $774,054 which gives an average price per flask of $39.33. Of the above, California produced 15,396 flasks valued at $605,054 and Arizona, Nevada and Texas 4285 flasks valued at $168,529.

STATISTICS OF QUICKSILVER IN THE UNITED STATES.

Year.	Production.					Exports.			Imports.	
	Calif. (a)	Texas.	Others.	Total.	Value. (f)	Flasks.	Metric Tons.	Value.	Pounds.	Value.
	Flasks.	Flasks.	Flasks.	Metric Tons.						
1899	29,454	261	.....	1,025	$1,416,790	16,518	573	$609,586	131	$ 83
1900	26,317	1,700	233	974	1,279,436	10,702	353	425,812	2,616	1,051
1901	26,720	2,932	75	1,031	1,382,305	11,219	389	475,609	1,441	789
1902	29,552	5,252	.....	1,208	1,515,714	13,247	459	575,099	*Nil.*	.....
1903	32,094	5,029	.....	1,288	1,564,734	17,575	610	719,119	*Nil.*	.....
1904	28,876	5,336	700	(c)1,204	1,848,185	21,064	731	841,108	212	160
1905	24,655	5,000	1,050	1,045	1,217,652	13,460	458	497,470	2,690	1,710
1906	19,516	4,517	1,276	861	1,035,138	6,455	220	244,299	84	50
1907	(d)17,532	3,000	400	712	868,678	5,132	175	192,094	16,566	6,719
1908	(d)16,969	2,832	346	685	903,391	2,995	110	124,960	15,113	8,215
1909	16,217	4,188	810	704	941,233	6,803	231	266,243	15,968	8,203
1910	(d)18,536	3,382	500	763	1,054,991	1,923	65	91,077	667	381
1911	18,860	(g)2,396	....	732	989,254	291	10	13,995	471,944	251,386
1912	20,600	2,700	1,847	855	1,067,742	310	14	13,360	82,706	39,919
1913	15,396	(h)	4,285	670	774,054	1,140	39	43,574	152,375	66,943

(a) Reported by the California State Mining Bureau, except 1907–08–10–11. (b) Included in "Other States." (c) Estimated; the weight of the flask was changed from 76.5 lb. to 75 lb. within this year. (d) Figures collected by the MINERAL INDUSTRY. (f) Computed at average price at New York. (g) With Nevada. (h) Included in other states.

Imports and Exports—Exports of quicksilver from the United States for the calendar year 1913 amounted to 85,521 lb. (1140 flasks), valued at $43,574. In 1912 the exports were 23,283 lb. valued at $13,360, and in 1911 they were 21,841 lb., valued at $13,995. The imports entered for consumption are estimated for 1913 at 152,375 lb., valued at $66,943, against 82,706 lb., valued at $39,920 in 1912, and 471,944 lb., valued at $251,386, in 1911. The greater part of the imports for 1913 were received in the last half of the year, and the above estimates may prove too high, as exact records are available for only the first 9 months of the year.

Market.—The primary market for quicksilver in the United States is San Francisco, California being the largest producer. The price is fixed in the open market, and, as quoted, is that at which moderate quantities are sold. Buyers by the carload can usually obtain a slight reduction, and those wanting but a flask or two must expect to pay a slightly higher

price. Average monthly quotations, in dollars per flask of 75 lb., are given below:

	1913.		1913.
January	39.37	July	41.00
February	41.00	August	40.50
March	40.20	September	39.70
April	41.00	October	39.37
May	40.25	November	39.40
June	41.00	December	40.00

The change in the import duty from 7 cents per pound to 10 per cent. *ad valorem* made an average reduction of about $1.50 per flask. This, coupled with the general tendency of the different selling agencies to force the market to make sales for their particular metal brought the average price down to between $4 and $5 lower than the established in London price plus duty and freight. The following table shows imports and exports for the United Kingdom.

	Imports.	Exports.	Price.	
	Flasks.	Flasks.	Highest.	Lowest.
			£ s d	£ s d
1909	43,163	22,050	9 17 6	7 19 0
1910	44,595	24,748	9 15 0	7 9 0
1911	46,547	31,438	10 0 0	7 10 0
1912	47,261	32,240	8 12 0	4 8 5
1913	45,348	28,816	7 15 0	7 0 0

California.—The New Idria mine in San Benito County continued to maintain the largest production in the United States., the Guadelupe in Santa Clara County second and Chisos in Brewster County, Texas, third.

Operations at the New Idria mine continue to demonstrate the almost inexhaustible supply of mercury ores that occur in the oldest of Coast range formations, and of the consistency of this belt of material that extends from Lake County in the north to San Luis Obispo County in the south.

At the Oceanic mine in San Luis Obispo County operations are proceeding with very satisfactory results. Mr. Murray Innes of San Francisco recently purchased this property from the Oceanic Quicksilver County of Los Angeles. Mr. Innes reports that during the past year he has developed 300,000 tons of ore with a tenor from 8 to 10 lb. per ton, that the ore is very even in grade, that the vein is from 20 to 40 ft. wide and that the shoot is 800 ft. in length. A shaft from the present fourth level is under way, the intention being to sink to a depth of 500 ft.

It will be interesting to learn what the geologic conditions are when the

shaft at the Oceanic mine penetrates the sandstone and enters the metamorphic formation.

At the Guadelupe mine in Santa Clara County the furnaces have been running continuously and it is said that developments in the mine have demonstrated that more ore is available than was extracted in 1913.

At New Almaden, the Quicksilver Mining Co. ceased mining in June at the time of the reorganization of the company. Since that time the furnaces have been operated from ore gleaned from old dumps by sorting. The company contemplates an extensive development program during 1914.

This development program will probably consist of exploring that territory between Mine Hill, where the old mine was situated, and the El Senidor mine about 3 3/4 miles away. Most of the ore mined at New Almaden for the past few years has come from the El Senidor and the possibilities of more ore in this mine is most promising.

At the Helen Mine in Lake County production has been curtailed while extensive development was proceeding.

Numerous small producers produced a little metal during the year but owing to the market conditions this production was not as great as in 1911 and 1912.

Texas.—The Chisos mine in Brewster County continued to operate throughout the year. Other activities in the Texas field consisted of prospecting and development only.

Arizona.—In Arizona, the Cinnabar Development Co. operating the old Colonial mine in west central Yuma County failed to report any production. It was rumored that a set of retorts was contemplated at this mine to work the rich ore that was found on the lower levels.

The Sunflower Cinnabar Mining Co., with headquarters at Phoenix, Arizona, have taken on a property near Cline in Gila County and are expected to begin the erection of a furnace immediately.

Nevada.—The Mercury mine at Ione, Nevada, continued to operate its furnace throughout the year. The Nevada Cinnabar Mining Co. completed the erection of a 50-ton plant on the Ione property. The plant consists of a double four-tile Mirabel type Scott furnace and eight double condensers. The plant itself is one of the best ever built but the situation and arrangement could have been more convenient and better adapted to the delivery of the ore from the mine. The common brick for the furnace were made on the ground from a comparatively weak clay full of sharp angular bits of rhyolite, the molding was done with a soft mud machine; the result was a hard, square, almost perfect brick far superior to the common slop brick.

The Ruby mine, situated about 5 miles south of Imlay in the Humbolt range installed a battery of twelve 12-in. pipe retorts during the year and had a very satisfactory run. It is proposed to erect a furnace on this property during 1914.

The Nevada Quicksilver or Goldbank Quicksilver mine situated about 40 miles south from Winnamucca has done considerable developing and has exposed the largest single deposit of cinnabar in the state. There is not a great deal of very high-grade ore present but large quantities of commercial ore is exposed and so situated that it can be mined at a low cost per ton. The metal occurs generally in an imperfect agglomerate. The agglomerate lies quite flat in parallel bedding, varying in thickness from 1 ft. to 4. These reefs of agglomerate alternate with strata of altered rhyolite varying from a few inches to several feet in width and thoroughly saturated with cinnabar. At a distance of approximately 300 to 400 ft. is a strong fissure filled with opaline material that carries a little cinnabar. The evidence of hot water circulation is very clear and the relation of this main fissure to the ore-bearing material will prove a most interesting study as the work progresses.

Upon locating the points on the map where mercury occurs in Nevada it is interesting to note the directness of the course between them. Beginning at the Pine Forest range (reported in 1899) in the north thence to the Ruby mine just south of Imlay, thence to the Goldbank in the East range, thence to the Mercury and Nevada Cinnabar at Ione, thence to the several deposits about Round Mountain, Manhattan and Belmont, thence to a deposit reported as 20 miles east of Goldfield, thence to the Fluorine district 5 miles east from Beatty. The above named include fully 90 per cent. of the reported occurrence of the metal and when these points are plotted on the map they are practically all in a straight line.

A report of discovery of rich cinnabar ore at Mina Nevada was published during the year but no authentic information regarding this find is available.

Foreign Countries

Austria.—The state mines continued operations during 1913 employing about 1000 men. The furnaces employed about 225 men.

Australia.—The Palganbar Quicksilver & Copper Mining Co. erected a small Livermoore type furnace on their property on Palganbar creek near Grafton, N. S. W.

Italy.—Monti Amatia mines continued mining and reduction of comparatively low-grade ore during the year.

Mexico.—Very little mining was done during the year due to the

unsettled condition of the country. The Guadalcacar mine near San Louis potosi produced about 1000 flasks early in the year.

Peru.—At the Huancavelica mine "busconeros" produced a small amount of metal.

Russia.—The discoveries of cinnabar in the Verch Isset district near Neviansk that were reported in 1912 evidently have not been followed by any discoveries of deposits of any magnitude, as no further reports of the district have been noted.

Spain.—The production of Spain, as estimated, was less than for 1912; probably between 52,000 and 53,000 flasks. There were no new discoveries or new mines reported to have been found or opened. The Almaden continued to be the principal producer with the other twenty-seven properties contributing a normal output.

United Kingdom.—The imports into the United Kingdom for the year amounted to 45,348 flasks with 26,816 flasks exported. Allowing 14,000 flasks as the home consumption this leaves a balance of 4532 flasks to accumulative stock for the year.

RADIUM

By Siegfried Fischer

General.—New determinations of the atomic weight of radium were made by O. Honigschmid as 225.93 and by R. Whytlaw Gray and Wm. Ramsay as 226.36. The rate of decay of radium compared with an equal amount of uranium was found to be 2,500,000 times as great. Much work has been done in studying the physical and therapeutical effects of the radium rays. Of interest is that the rays impede the longitudinal growth of the plant buds, while radioactive emanations as a whole favor the growth of plants. This phenomenon has also been observed when radium emanations were applied to human beings. The unfiltered rays have a destroying influence on the normal cells, mostly due to the action of the α rays. The application of radium rays in therapeutics is still under investigation, but one thing has been definitely decided upon by all investigators, namely, that the α rays must be filtered out. This is accomplished by filtering the rays through lead, special lead filters being made for this purpose. The β rays stay with the α rays so that only the γ rays are applied to the infected surface. Some physicians attribute healing qualities to the β rays as well as the γ rays, and investigations are going on at the present date to determine the beneficial effects of these rays. Sir. Wm. Ramsay has made an interesting statement before the British Radium Corporation to the effect that radium could not be administered to the human body, due to its dangerous results and its difficult elimination from the system.

However successful treatment of a number of different diseases have been claimed during the course of the year 1913 by physicians in Europe and America.

Dr. S. Saubermann, of Berlin summarizes the physiological effects of radium emanation as follows:

Radium promotes the growth and multiplication of the healthy cells, while morbid cells decay; increases the secretion of urine; stimulates activity of the digestive tract; increases the secretion of uric acid in urine; dilates the blood vessels; decreases the viscosity of the blood; lowers the blood pressure; increases metabolism, especially of the hydrocarbons; soothes the nerves and relieves insomnia; increases sexual activity.

The use of radium being restricted to therapeutical purposes, the effects along these lines have been dealt with more in detail. A summari-

zation of the investigations of the physical properties of radioactive rays may be found in the *Chemical Abstracts* of the American Chemical Society.

The marketable salts of radium are, radium bromide, radium chloride, radium sulphate and radium carbonate.

Radium bromide, $RaBr_2 2H_2O$ contains	53.5 per cent. radium.
Radium chloride, $RaCl_2$ contains	76.8 per cent. radium.
Radium sulphate, $RaSO_4$ contains	70.2 per cent. radium.
Radium carbonate, $RaCO_3$ contains	79.0 per cent. radium.

These values would make

1 mg. of Ra equal to	1.87	mg. radium bromide.
	8.42	mg. radium sulphate.
	1.31	mg. radium chloride.
	1.265	mg. radium carbonate.

The Committee for an International Radium Standard gives out the following:

1 Curie: quantity of radium emanation in equilibrium with 1 grm. of radium element.

1 Millicurie: quantity of radium emanation in equilibrium with 1 mg. of radium element.

1 Microcurie: quantity of radium emanation in equilibrium with 1 microgram of radium element.

1 Milligram minute: quantity of radium emanations produced in 1 minute by 1 mg. of pure radium bromide.

1 Electrostatic unit (e.s.u.): current measure, 3.33×10^{-10} (0.000000000333) amp.

1 Mache unit (m.u.): saturation ionization current due to radium emanation from a liter of solution of gas expressed in electrostatic units multiplied by 1000.

Sources of Radium.—The main sources of radium are the same as in previous years, namely, the pitchblende and carnotite. To these may now be added the autunite deposits of Portugal and Australia and the kolm of Sweden.

A new vein of pitchblende has been discovered in the Porcupine district in Ontario, Canada, which shows a greater percentage of radium than the ores from Austria, England and the United States.

About 22 1/2 miles from Baltimore, Maryland, radium was discovered in a feldspar mine near Laurel.

An ore found in the Mudgee district of New South Wales has shown the presence of radium.

Radium has also been discovered in some mineral springs in Russia, especially those near Sotobi and Sukhum in the Caucusus.

Regarding the distribution of pitchblende and carnotite, *Bulletin* 70 of the Bureau of Mines gives a detailed description.

In Japan thorianite containing ThO_2 60 to 78 per cent. and UO 15 to 33 per cent. is being treated for radium and mesothorium.

Technology.—Some marked improvements have been made in the methods of extraction of radium from its ores. Prof. Dr. Ebler of Heidelberg has refined the Curie-Debierne process of radium manufacture. The Curie-Debierne process in short is: 1. To lixiviate the finely ground material with sulphuric acid; vanadium and uranium are dissolved and the residue retains the radium and the mesothorium. 2. The residues are concentrated by a series of lengthy operations down to about 1 per cent. of their original weight. 3. The raw sulphates from 2 are worked to pure radium-barium chloride. 4. This last product is converted by fractional crystallization into pure chloride or bromide.

The improvements by Dr. Ebler refer to stages 2, 3 and 4 of the operation. He proposes to reduce the raw sulphates from 2 autogenously by mixing them with calcium hydride. He obtains by this means soluble sulphides or oxides which he extracts with muriatic acid obtaining the radioactive substances as chlorides. The operation is very rapid and of high efficiency, giving 90 per cent. of the original radium content of the ore. He claims that by suitable means the operation could be applied to the ore directly. His second improvement deals with the step 4 in the Curie-Debierne process. He effects the concentration of the radium contained in the radium-barium chloride by fractional adsorption of the radium and barium respectively to the colloidal peroxide hydrate of manganese; this is followed by a desadsorption and the step repeated until pure radium chloride is obtained. The intermediate products formed may be used directly for radium-barium preparations.

The process used by the Société Française du Radium at Gif near Paris is worthy of mention. The ore treated contains radium, uranium, actinium, polonium, ionium and their derivatives. It contains no thorium or mesothorium. It is first pulverized and treated with HCl, then filtered and the residue discarded. The solution contains, Ra, U, Ac, Io and Po. From this solution the Ra and Ba are precipitated as sulphates and filtered out; the filtrate contains U, Ac, Io, Po and is neutralized with $CaCO_3$ and precipitated with Na_2CO_3 in excess. The Na_2CO_3 solution contains uranium which is obtained as uranate by decomposing the solution with alkali. The precipitate containing the oxides of Ac, Po and radioactive by-products is treated separately for the Ac, Io and Po. The residue containing the insoluble sulphates of Ra, Ac, Po, Io is treated with Na_2CO_3 and filtered. Filtrate is not radioactive and is eliminated. The residue is treated with HCl and converts carbonates into chlorides which are purified with alkalies then filtered. The precipitate containing Ac, Po, Io and small amounts of Ra is treated

for these elements. The filtrate of $RaCl_2$ is concentrated by fractional crystallization by two steps, first by converting chlorides into bromides and then separating the bromides.

A new process for the extraction of radium from kolm has been established in Sweden and also one for the treatment of fergussonite. Details are kept secret.

In Portugal austunite running as low as 0.3 per cent. of U_3O_8 is being successfully treated with hydrochloric acid.

The treatment of the Olary radium ores was described in MINERAL INDUSTRY, XXI.

Radium Supply.—Mr. Paul Blesson claims, that the total amount of metallic radium on hand at the present time is 7 grm., of which Mme. Curie owns 3 grm.

Market and Demand.—The demand for radium salts is increasing steadily. Germany is especially active in buying up radium compounds. The price of radium bromide fluctuated between $70 to $100 per milligram during 1913. The latest figure quotes the price of 1 oz. of metallic radium as £480,000 or $2,332,800.

United States.—Great activity has been shown in the radium field during 1913. The government has decided to pass a bill preventing all the radium ores being shipped to Europe. Furthermore the Bureau of Mines has been authorized to investigate the most economical means of producing radium for the use and benefit of the country. The Radium Institute has been founded. Its object is to work in conjunction with the Bureau of Mines on methods of mining, concentrating and extracting radium, uranium and vanadium from carnotite. The directors are Dr. H. A. Kelly, James Douglas, Dr. C. F. Burnham and A. Douglas. The corporation has obtained the right to operate 29 claims to the Paradox Valley, Colo., and an experimental plant will be erected in Colorado.

The basis on which ore is bought has been changed, nothing being paid for the vanadium content, but solely for the uranium. To compensate for the vanadium a higher price is being paid for the uranium.

The output for the year 1912 was 8.8 grm. $RaCl_2$ or 11.43 grm. $RaBr_2$ based on the ore shipped, amounting to a value of $792,000, basing the price per gram of chloride at $90,000.

The output for the year 1913 was 8.97 grm. metallic radium, equivalent to 16.40 grm. hydrous RaBr based on the ore shipped. At $120 a milligram of metallic Ra, this would amount to $1,055,000. Of this 16.4 grm. of hydrous bromide, 8.3 grm. were shipped to Europe, and 8.1 grm. were retained in this country.

It is of historic importance to know that the Standard Chemical Co. of Pittsburg, Pa., was the first American firm to produce radium in this

country. It is claimed that a shipment of radium amounting to £25,000 was made to France by this company, and it is well known that the same firm shipped 133 mg. of anhydrous $RaBr_2$ to a well-known physician in Baltimore.

A new plant has been erected at Sellersville, Pa., by the Radium Co. of America for the extraction of radium.

A mill for the treatment of the feldspar containing Ra, has been constructed at Laurel, Maryland.

Austria.—Austria for the past few years has only treated 3 to 4 tons of pitchblende annually. The production would not exceed 2 grm. The product produced is used in that country, as it is forbidden to export it.

France, Portugal and Sweden together furnished about 1 grm. New companies in these countries are: The Kolm Co. of Islinge near Stockholm, Sweden, and the Société Française du Radium at Gif near Paris, France.

England and Germany.—It has been estimated that the output for these two countries amounts to 1 grm.

Total European output during 1913 was 4 grm. of pure radium salts

Australia.—The production of radium salts from Australia is estimated at 2 grm. of pure salt. That the Radium Hill Co., Olary, S. Aus., is progressing may be seen from the fact that the shareholders decided to increase the capital of the company from £40,000 to £80,000.

Bibliography

Curran, T. F. V.—Carnotite, The Principal Source of Radium.

Moore, R. B., and Kithil, K. I.—*Bulletin* 70, Bureau of Mines.

Parsons, C. L.—The Uranium Radium Situation. *Min. Sci. Pr.*, May 17, 1913, p. 741.

————. Radium Produced in France from Cornish Ore. *Min. Jour.*, Nov. 22, 1913.)

Rutherford, E.—Radio-active Substances and Their Radiations. *Cambridge Univ. Press.*

Soddy, F.—The Interpretation of Radium. Putnam Pub. Co., New York.

Marx, Erich.—Handbuch der Radiologie. Four volumes. *Akademische Verlagsgesellschaft m.b. H.*, Leipzig.

Rutherford, E.—Radiumnormalmasse und deren Verwendung bei radioaktiven Messungen. *Akademische Verlagsgesellschft m.b. H.*, Leipzig.

Ramsay, Sir W.—Die edlen und die radioaktiven Gase. *Akademische Verlagsgesellschcft m.b. H.*, Leipzig.

London, E. S.—Der Radium in der Biologie und Medizin. *Akademische Verlagsgesellschaft m.b. H.*, Leipzig.

Curie, Mme. P.—Die Radioaktivitat." Two volumes. *Akademische Verlagsgesellschaft m.b. H.*, Leipzig.

Curie, Mme. P.—Die Entdeckung des Radiums. *Akademische Verlagsgesellschaft m.b. H.*, Leipzig.

SELENIUM AND TELLURIUM

By A. S. Callen

During the past year there have been no essentially new developments in the metallurgy of selenium and tellurium, since there is a very small market for these two elements. However, there is a larger market for the selenium than for tellurium. Both metals are obtained from copper refineries where they form a good percentage of the slimes from the electrolytic tanks, and are recovered from the flue dust from the slimes smelting furnaces or by direct roasting of the slimes.

The 1913 production amounted to about 10,000 lb., of which about 9000 lb. were exported. The exports of tellurium amounted to about 60 lb. The price of selenium has remained practically constant. That is between $2.75 and $3.50 per pound in large lots and $4.50 to $5.50 at retail.[1]

Returns from the various copper refineries indicate that enormous quantities of these metals could be supplied if uses were developed for them. Several hundred tons could be supplied at once, in the United States alone, if a demand were created, and the possible supply, under a heavy demand, would probably run into the thousands of tons.

The selenium which is produced is chiefly used in the manufacture of red glass and red enameled ware. It has been found that the dioxide does not color the glass but that if reduced by carbon, by arsenic trioxide or by fusing in a reducing atmosphere the red color is obtained. However, it is probable that the color is not due to colloidal metallic selenium but to the presence of a selenide for on solution of the glass in hydro-fluosilic acid we have hydrogen selenide evolved which indicates a selenide in the glass. The other uses of selenium are mainly laboratory uses such as in the manufacture of selenium salts and in the production of selenium cells for experimental work. Small amounts are also used in medicine.

[1] *Eng. Min. Jour.*, Jan. 17, 1914.

SILICA

The compound silica makes up approximately 60 per cent. of the known portions of the world's crust, and in its free state is used commercially in a number of different forms, the chief of which are sands of various kinds, silex or flint, quartz, sandstone, rock crystal, agate, onyx, opal, tripoli, pumice, and kieselguhr or diatomaceous earth.

Of the various forms the production is so scattered that complete statistics cannot be collected. Hence only a few of the more important varieties of the mineral will be considered.

Diatomaceous Earth

By P. A. Boeck

Formation.—Diatomaceous earth, or kieselguhr deposits are formed by the precipitation of the remains of bacillariæ or diatoms, one of the groups of flowerless aquatic plants of the species "algæ," which occur almost universally in all waters from arctic to torrid, fresh or salt, still or running. There are innumerable varieties of diatoms, over 4000 distinct forms having been classified and described. These vary greatly in size from that of a head of a pin easily visible to the naked eye, down to such a minute size as to be revealed only by the highest power of the microscope.

The silica shell or casing of these plants is secreted by the assimilation of inorganic substances in solution in the water about them through the agency of sunlight in conjunction with the chlorophyl masses which compose the bodies of the plants. Diatoms multiply with great rapidity and float about in the water or on its surface while living. When the organism dies it sinks to the bottom where the countless myriads of shells accumulate, carrying down with them varying amounts of undecomposed organic matter of which a part remains even centuries after.

Composition.—The accumulations of these diatomaceous shells is in most deposits contaminated by interposed impurities which also settle to the bottom of bodies of water or are carried along with the sinking diatoms. This may be in the form of diatomaceous ooze, silt, clay, sand or volcanic ash and other inorganic materials from which it is commercially impossible to separate the diatoms.

Sample (1) Very light-weight pure white kieselguhr.
(2) Light-weight brownish kieselguhr.
(3) Compact diatomaceous shale.

	(1)	(2)	(3)
Silica (SiO_2)	88.78 per cent.	85.28 per cent.	94.59 per cent.
Alumina (Al_2O_3)	2.68	5.35	1.87
Iron oxide (FeO)	trace	1.12	0.76
Titanium oxide (TiO_2)	0.10	0.21	0.10
Lime (CaO)	1.61	1.12	0.83
Magnesia (MgO)	1.30	1.30	trace
Loss on ignition	5.54	5.57	2.22
Color	White	Ivory	White
Color after ignition	White	Pink	White

In its natural state kieselguhr contains from 25 to 45 per cent. of moisture which is expelled at 100° C., and is pure white to brownish, very light weight, soft, easily abraded material. The condition of the silica, its principal constituent, is one of the characteristic properties, it being in the amorphous or opaline state carrying ordinarily from 5 to 10 per cent. of combined water. In many cases this silica has been erroneously reported by some of the older writers as "colloidal silica," this term being used synonymously with amorphous silica, due in all probability to the vague understanding of the term. This, however, must not be taken to indicate that kieselguhr has no colloidal properties, for as a matter of fact these properties are strongly marked but variable, similarly as in a great many clays and show a decided absorption with malachite green oxalate. In certain cases a higher absorption of this dye is obtained by kieselguhr than on samples of Fuller's Earth, in which the bleaching or clarifying action has been shown to be due to a large extent to the physical condition of absorption and dependent on the colloidal content of the earth. The condition of the silica in kieselguhr is further indicated by the fact that it is easily decomposed by means of hydrofluoric acid, is soluble in solutions of sodium carbonate of all strengths and yields water on heating in a closed tube. The specific gravity of kieselguhr is approximately 2.1 to 2.2 at 25° C.; indicating that it is amorphous silica, which is usually taken as 1.9 to 2.3.

Properties.—The general characteristics which make kieselguhr of great commercial importance for various purposes may be outlined as follows:

I. *Physical.*

(a) Form.
  (1) Enclosed air cells.
  (2) Large exposed surface of cells.
  (3) Fine state of division.
  (4) Sharpness of cells.
  (5) Weakness or low compressive strength of cells.

(b) Refractory nature.

(c) Presence of large amount of colloidal material.

(d) White color.

II. *Chemical.*

(e) Siliceous or inorganic nature.

(f) Easy solubility in alkalies.

(g) Insolubility in acid or neutral solutions.

Light Weight.—The apparent specific gravity of the raw blocks, as they are mined, after drying, varies considerably, depending upon the amount of material transformation which has taken place at the particular deposit. The apparent density of the dry, crude blocks is about 0.45 equivalent to 28 lb. per cubic foot, while that of the pulverized material, made from them, when loosely packed, has an apparent density as low as 0.13, equivalent to 8 lb. per cubic foot, which can be doubled with packing. In other words, in 1 cu. ft. of the loose material there is but 0.058 of a cubic foot or 100.2 cu. in. of silica having a density of 2.2.

Thermal Insulator.—The microscopic voids or "dead air" cells in and between the diatoms form an excellent natural barrier to the passage of heat making it the most effective inorganic thermal insulator known. This application is one of the oldest and most important of the uses of this material. It has been found that even a slight increase in the weight or apparent density of this material has a marked effect in lowering its heat insulating value in addition to causing the material to settle and increasing the cost of transportation to the market.

This most important property of kieselguhr has been used extensively for the production of fireproof and incombustible insulator in the form of loose powder, solid natural blocks, burned insulating brick and tile, pipe covering, etc., for both high temperatures in ovens, cookers, furnaces, annealing pits, boilers, evaporators, stills and for low temperatures in cold storage and refrigeration plants, icehouses, iceboxes, coolers and similar purposes. It has the advantages over the organic insulating materials, some of which have a somewhat higher thermal resistivity in that it is unaffected by extreme heat or cold, and is not subject to decomposition, decay or any physical change with time.

Sound Deadener.—On account of the same physical properites this material has found extensive use as a "deadener" or sound proofing material.

Refractory.—As the diatoms consist chiefly of silica, a material which is in itself of a refractory nature, this valuable characteristic as a whole is imparted to kieselguhr. The melting point of natural powdered kieselguhr has been reported by the Bureau of Standards to be 1610° C. (2930° F.), and that of a lightweight diatomaceous shale 1750° C. (3182° F.), indicating its highly refractory nature. This feature, together with its low thermal conductivity, opens up a wide field for its use in the ceramic industries for the production of lightweight brick and

tile for insulating and refractory purposes. Owing to the low apparent density of the pulverized kieselguhr it has found extensive application for fire protection in buildings as a light fireproof wall filler. On account of its smothering effect caused by the exclusion of oxygen from the vicinity of the flame, it is also used as a fireproofing and insulating material in safes, ovens, fireless cookers, electric fuse protectors, etc.

The report of the State Mineralogist of California shows a production of 2194 tons in 1911 and 4129 tons in 1912.

PRODUCTION OF DIATOMACEOUS EARTH IN THE UNITED STATES IN 1913. (a)

State.	Quantity.	Value.
California, Nevada, and Washington	6,035	$55,056
Connecticut, New York, and Maryland	328	8,065
Virginia, Georgia, and Florida	239	6,183
Total	6,602	$69,304

(a) Mineral Resources of U. S., 1913.

Flint

Flint Production.[1]—So far as can be learned no flint (proper) or chert was produced for consumption as silica or for use as pebbles in grinding mills in the United States in 1913.

Imports.—The imports for consumption of flint pebbles into the United States in 1913 were valued at $319,509, as compared with $292,052 in 1912, $236,158 in 1911, $307,286 in 1910, and $301,547 in 1909:

The following table shows the value of imports of flint pebbles in 1913 by country of origin:

IMPORTS OF FLINT PEBBLES, UNGROUND, INTO THE UNITED STATES, 1913, BY COUNTRIES

Belgium	$40,947	Germany	$2
Canada	8,599	Newfoundland	10,800
Denmark	134,625	Sweden	56
England	2,626		
France	121,854	Total	$319,509

Glass Sand

By Henry B. Kümmel

Sand suitable for the manufacture of glass is widely distributed, but its production is chiefly confined to Pennsylvania, Illinois, West Virginia, Ohio, Missouri, New Jersey, Indiana and California. In twelve other states one or two firms have reported small amounts but their combined total is less than 4 per cent. of the entire production of the country.

Pennsylvania produces about 36.0 per cent. by value of the total, California less than 1 per cent. and the other states mentioned rank between

[1] F. J. Kats, Mineral Resources of U. S., 1913.

these in the order given. During 1913 the total production was 1,791,800 short tons, valued at $1,895,991.

Only sands high in silica (99 per cent. plus) and with very minute amounts of iron or clay can be used in the manufacture of glass. For the finest flint ware in which absolute transparency and great brilliancy are required, the purest sand must be used since even minute amounts of iron impart a greenish color to the glass. Plate and window glass are usually pale green and can be made of sand carrying a slight amount of iron, but as frequently stated the ferric oxide should be less than two-tenths of 1 per cent.[1] Green and amber glass, such as is used in bottles, jars and rough structural work can be made of sand with larger amounts of iron.

Accurate analysis of even high-grade glass sand always shows small amounts of one or more of the following substances: Iron, alumina, titanium oxide, lime, magnesia and organic matter, and an absolutely pure silica sand is unknown. These substances frequently are due to other mineral grains than quartz, usually present in the sand, such as mica, magnetite, feldspar more or less altered to kaolin, ilmenite, spene, rutile, etc., or to films of iron oxide or clay coating the quartz grains. Some of these substances, particularly mica, clay, etc., are removed by washing the sand. Others, such as lime in the form of carbonate and present as bits of shell or ground up limestone or such as oxides of sodium or potassium can hardly be classed as impurities, since they are added to the sand in the manufacture of glass. Others like the iron-bearing minerals are highly injurious because of the green color which iron even in small quantities imparts to the glass.

Magnesia renders the glass batch more difficultly fusible, but it is more likely to be introduced in the mixture with the limestone than with the sand. The following analyses show the composition of some grades of glass sand.

Sample No.	Silica SiO_2.	Iron Oxide Fe_2O_3.	Alumina Al_2O_3.	Titanium Dioxid TiO_2.	Lime CaO.	Magnesia MgO.	Organic Matter and Moisture	Analyst.
New Jersey 1....	99.40	0.0058	0.2752	0.0737	0.008	0.012	0.231	R. B. Gage, N. J. Geol. Surv.
New Jersey 2....	99.62	0.0047	0.1420	0.0543	0.010	0.005	0.162	R. B. Gage, N J. Geol. Surv
New Jersey 3....	99.54	0.0039	0.2245	0.0476	0.007	0.009	0.166	R B. Gage, N. J. Geol. Surv.
New Jersey 4....	99.55	0.0049	0.1443	0.0608	0.008	0.011	0.22	R. B. Gage, N. J. Geol. Surv.
New Jersey 5....	99.11	0.0108	0.3550	0.2213	0.009	0.023	0.19	R. B. Gage, N. J. Geol. Surv.
New Jersey 6....	99.176	0.0114	0.3660	0.2344	0.011	0.019	0.182	R. B. Gage, N. J. Geol. Surv.
Penn. 1.....	99.72	0.0017	0.1203	0.0147	0.007	0.008	0.134	R. B. Gage, N. J. Geol, S urv.
West Va. 1.....	99.60	0.0286	0.4214	not det	not det	not det	not det.	West Va. Geol Surv.
West Va. 2.....	99.30	0.0314	0.5186	not det	not det	not det	not det.	West Va. Geol. Surv.

[1] Analyses given in the table show less iron than many published analyses of sands used for similar grades of glass, but in these cases no determination of titanium oxide was given. Since refined analyses show that titanium in some form is nearly always present in rocks, clay and many sands, and since in making an analysis titanium oxide if present will be included in the ferric oxide uhless separately determined, it is quite probable that this is too high. Certainly the analyses made by the New Jersey Geological Survey indicate that sand containing two-tenths of 1 per cent. ferric iron (the titanium oxide being separately determined) cannot be used without correction for anything but low-grade glass.

The New Jersey sands numbered 1 to 4 are used chiefly for window, green and amber glass and are often used for flint glass but when so used have to be corrected for color. Sands like New Jersey 5 and 6 are used for cheaper grades of glass where color makes little difference, as in beer bottles. Pennsylvania 1 is a sand used extensively by New Jersey glass manufacturers for the best grades of flint glass.

It is often stated that sand grains must be sharp and angular, but this claim does not appear to be well founded since much glass is made in the Mississippi Valley of well rounded and smooth sand. The grains should be fairly uniform in size and neither too small nor too large. If the majority passes a sieve having 120 meshes per linear inch the sand is said to "burn out" in the batch and not to produce as much glass per unit as when composed of coarser grains. The fine grains also tend to sink to the bottom of the batch and thus prevent the formation of a homogeneous mixture. If the grains are uniformly larger than will pass a 30-mesh sieve, more time is required to fuse them. Hence the per diem production of glass is lowered and the cost increased. In many New Jersey glass sands, 60 per cent. of the grains pass a 40-mesh sieve but are retained on a 60-mesh (*i.e.*, range in size from $\frac{1}{35}$ to $\frac{1}{60}$ of an inch in diameter). Usually only 25 per cent. pass a 120-mesh sieve ($\frac{1}{117}$ inch), and less than 2 per cent. are larger than 30 mesh.

The consumption of glass sand has been increasing and there is no doubt but the increase will continue. The supply is practically inexhaustible and widespread. In the ground, glass sand has very little value, the market value being due to the labor expended upon it. The possible value of a deposit for development depends upon numerous factors. Some of these are: 1, chemical purity; 2, physical character; 3, quantity available; 4, cost of quarrying or mining as determined by cost of fuel to run machinery, cost of labor, amount of stripping necessary, hardness of rock, etc.; 5, accessibility to market both as to distance and means of transportation.

The importance of shape, size and chemical composition of glass sand have already been emphasized, but these are not the only factors to be considered. Since a modern plant for digging, crushing, washing, and loading glass sand costs not a few thousand dollars, a large supply of high-grade sand must be available to warrant this investment. At prices prevailing, the margin of profit is low and therefore cheap fuel, cheap labor and low costs for quarrying are essential. Sand is extremely bulky and heavy in comparison with its value, so that freight rates are relatively high, which tends to limit the radius of shipment. Only the highest grade sands will stand distant transportation. The best Pennsylvania sands are shipped from the central and western part

of the State to glass manufacturers in Southern Jersey in competition with local sands, but this is only possible because of their better grade.

Pennsylvania.—The glass-sand production in 1913 in Pennsylvania, which is the chief producer, was the greatest on record, approximately $700,000 in value. This was chiefly from the counties of Armstrong, Elk, Venango, Warren and Westmoreland. It is practically all derived from crushed sandstone of Oriskany age, particularly in Huntington and Mifflin counties, where this formation is frequently brought to the surface by extensive folding. In Westmoreland and Fayette counties portions of the Pottsville formation (the Homewood sandstone) have been used. The Oriskany sandstone, where most extensively quarried has a thickness of 75 to 150 ft., but only a portion (usually the upper part) is of sufficient purity to be used in glass making. Where quarried for glass sand the rock has been extensively leeched of its impurities and although it often carries a considerable percentage of lime and contains many fossils, in the rock quarried the fossils are represented only by casts. The Oriskany is less resistant and hence more readily crushed than other sandstones of the state which are of sufficient purity to be suitable for glass sand. Hence the cost of preparation is less and the use of the harder sandstones is circumscribed by their proximity to market. The average value per ton is about $1.20 to $1.22 at the quarries.

Illinois.—The glass-sand industry in Illinois is centered in LaSalle County near the junction of the Illinois and Fox rivers, where valleys are cut in the flat-lying St. Peters sandstone near the cities of Utica and Ottawa. Two railroads traverse the broad Illinois River valley at Ottawa and afford favorable transportation facilities. In this vicinity the St. Peters sandstone has a thickness in excess of 300 ft. but only 60 to 75 ft. of sand are worked on account of heavy ground water. The rock is very friable and breaks down almost completely in blasting. It is then readily washed down by streams from small nozzles, carried through sieves, and pumped to the mills where it is washed, dried, screened and made ready for shipment.

The sand from this locality is sold for all grades of glassware. The best sand is used for cut glass and pressed glass, and much is sold for flint glass and bottles. Published analyses[1] of these sands show 99.45 to 99.89 per cent. of silica and iron from traces up to 0.09 per cent.

Illinois is next to Pennsylvania in the amount of glass sand produced but owing to the low prices of glass recently prevailing in this state—70 to 80 cents per ton—the aggregate value has been less than in West Virginia, where higher prices prevail.

[1] *Min. Res. of U. S.*, 1911, Pt. II, p. 624.

West Virginia.—Berkeley Springs, Morgan County, in the northeastern part of the state is the chief producing center, but subordinate amounts are mined in Preston, Monongahela and Upshur Counties. Near Berkeley Springs, quarries have been opened in both the Oriskany and the Medina white sandstone, but the Oriskany is chiefly worked. In Preston, Monongahela and Upshur Counties a white sandstone forming the upper member (the Homewood sandstone) of the Pottsville conglomerate is utilized. Probably 75 per cent. of the entire production of the state is from the Oriskany.

Although the outcrop of this formation is usually hard in the quarries, the sandstone is somewhat friable with occasional pockets of loose sand. When crushed, it readily crumbles into its constituent grains. Practically all the sand is washed after crushing. Analyses by the chemists of the West Virginia Geological Survey show that the silica ranges from 98.99 to 99.60, the iron oxide from 0.0286 to 0.154 and alumina from 0.199 to 0.5186. The annual production averages about 250,000 tons, valued at about $295,000 or from $1.15 to $1.20 per ton at the quarries.

Ohio.—Glass sand in Ohio is derived from three geological horizons. At Silica, Lucas County in the northwestern part of the state, sandstone of Upper Silurian age has been quarried for glass sand for many years and preparations are being made to increase greatly the output. The quality is said to be good. The Black Hand conglomerate which lies near the top of the Cuyahoga formation has been quarried for years at Toboso, between Newark and Zanesville, and at Rockbridge, Hocking County. This sand is used largely for bottles and other common grades of glass.

In the northeastern part of the state, especially in the vicinity of Massilon, Youngstown and Niles the Pottsville sandstone, which lies at the base of the coal measures and outcrops from the Pennsylvania line, southwest to Kentucky, is an important source of glass sand. The production is about 160,000 tons per year valued at from $1.06 to $1.10 per ton at the mines.

Missouri.—In Missouri the chief source of glass sand is the St. Peters sandstone, although the Roubidoux sandstone is capable of furnishing sand for the manufacture of glass in which color is not of prime importance. The St. Peters sandstone outcrops across eastern Missouri from Callaway to Cape Girardeau Counties in a general northwest-southeast direction. The chief centers of production are Pacific, Franklin County, Crystal City, Jefferson County and Klondike, St. Charles County. Although a sandstone, the St. Peters is so friable that much of the sand is dug loose and crushing is unnecessary. The annual production is about 130,000 tons which has an average value of 63 to 65 cents per ton at the quarries.

New Jersey.—The chief centers of the glass-sand industry in New Jersey, Millville, South Vineland and Williamstown, are in the southern part of the state. The sand occurs in the Cohansy formation and is Miocene or younger in age. Unlike the formations in most other states the glass-sand beds of New Jersey are incoherent and unconsolidated so that crushing is unnecessary.

The sand beds are, however, always covered by an overburden of gravel or of sand unfit for glass making which must first be removed. In some portions of the field, this overburden attains a thickness of 15 or 20 ft. Where it is of this thickness the value of glass sand beneath would not warrant the removal of such a covering of gravel were it not for the fact that it is usually of value for foundry purposes, rod metal and other uses.

The sand is dug in open pits either by being shoveled into casts and hauled to the washer or by being pumped suspended in water through a 4-in. or 6-in. pipe to the washer. Where the latter method is in use the pit is filled with water to a depth sufficient to float a small scow carrying a suction pump and other machinery necessary. With the intake pipe kept at the proper distance from the bank, the rushing water carries from 20 to 30 per cent. of sand.

It is first washed through an inclined revolving cylindrical screen which eliminates grains coarser than $\frac{1}{70}$ of an inch (30 meshes per inch) and then is carried up inclined flumes by scrubbers attached to endless chains. The clay and finest sand is carried off by the backward flowing water. With a medium-sized, well-equipped plant, 10 men can pump and wash 250 tons of sand per 10-hour day.

The average annual production is 100,000 tons or more, valued at nearly $80,000 or 75 to 80 cents per ton at the mine. The sand is used almost entirely in local glass houses, which also import considerable quantities of sand from Pennsylvania.

Indiana.—The Mansfield sandstone at the base of the productive coal measures of Indiana is the chief source of glass sand in that State, but the Pendleton sandstone has been used to some extent near the town of Pendleton in Madison County. The producing centers are Coxville, Park County, Green Castle, Putnam County, and Loogootee, Martin County, but the Mansfield sandstone is exposed along the valley sides in Warren, Fountain Clay, Owen Green, Dubois, Orange, Crawford and Perry Counties, so that the opportunities for developing other glass-sand centers are numerous, if transportation facilities are present and the necessary market can be obtained. As yet the production in Indiana is not of great importance, averaging only between 25,000 and 30,000 tons valued at about 40 to 45 cents per ton at the mines.

Michigan.—In Michigan glass sand occurs in the Sylvania or Middle Monroe sandstone and in the St. Peters sandstone, but only the former is developed and this only at two localities in Monroe County in the southeast part of the state. The Sylvania sandstone is generally incoherent, the grains being bound together by a very small amount of dolomitic cement. Locally the sandstone is indurated and requires crushing but in the pits now being operated a small stream of water is all that is necessary to disintegrate the rock. After washing, the silica is reported to be over 99 per cent. Since there are only two producers, the amount of production cannot be given.

Wisconsin.—In Wisconsin the St. Peters sandstone yields sand suitable for glass, but the production is small, being limited to an occasional carload by firms who dig chiefly other grades.

Other Sands.

Following is a table of domestic production of various grades of sand.

PRODUCTION OF SAND IN THE UNITED STATES. (a)
(In tons of 2,000 lb.)

	1912		1913	
	Quantity	Value	Quantity	Value
Glass Sand	1,465,386	$1,430,471	1,791,800	$1,895,991
Molding Sand	4,485,380	2,718,726	3,563,583	2,230,217
Building Sand	23,776,013	7,968,127	25,397,383	8,007,949
Grinding and Polishing Sand	1,285,863	632,136	941,373	540,399
Fire Sand	455,454	318,742	519,061	364,363
Engine Sand	1,288,616	428,986	1,033,450	401,806
Furnace Sand	51,446	27,258	3,335,508	1,020,389
Paving Sand	1,788,530	670,680	2,335,196	266,852
Other Sands	3,986,288	1,177,065	2,111,997	646,731

(a) U. S. Geological Survey.

Quartz[1]

Production.—The marketed production of silica from vein and pegmatite quartz and from pegmatite in 1913 was 97,902 short tons, valued at $201,488 against 97,874 short tons, valued at $191,685 in 1912. This was an almost inappreciable increase in quantity and an increase of $9,803, or about 5 per cent., in value. The decrease in the quantity sold crude was 7876 short tons, or about 11 per cent. with a decrease in value of $12,814, or about 24 per cent., whereas the quartz sold ground increased 8057 short tons, or about 34 per cent. in quantity and $23,617, or about 15 per cent. in value. The average price per ton for crude in 1911 was 91 cents; in 1912 it was 82 cents, and in 1913 it was 73 cents. The average price per ton for ground quartz in 1911 was $8.32, in 1912 it

[1] F. J. Kats, Mineral Resources of U. S., 1913

was $7.94, and in 1913 it was $6.23. In 1913, of the total marketed output, 75.76 per cent. was crude and 24.24 per cent. was ground, and of the total value received, 27.02 per cent. was for crude and 72.98 per cent. was for ground. The figures of the production of quartz for 1913 and previous years are based on complete returns from all known producers.

The following tables show the marketed production of quartz in 1912 and 1913 classified as to crude and ground, by states, and from 1909 to 1913 classified as to crude and ground:

MARKETED PRODUCTION OF QUARTZ IN THE UNITED STATES, 1912-1913, BY STATES, IN SHORT TONS.

1912.

State.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Connecticut, Massachusetts, and New York	5,802	$10,701	61	$1,758	5,863	$12,459
Maryland	10,130	15,369	5,995	46,782	16,125	62,151
North Carolina, Pennsylvania, and Tennessee	66,049	40,486	1,200	7,800	67,249	48,286
Other States (*a*.)	224	700	8,413	68,089	8,637	68,789
Total	82,205	67,256	15,669	124,429	97,874	191,685

1913.

Connecticut, Massachusetts, and New York	8,153	18,711	1,190	20,674	9,343	39,385
Maryland	194	565	7,664	54,877	7,858	55,442
North Carolina, Pennsylvania, and Tennessee	65,829	35,166	1,210	7,260	67,039	42,426
Other States(*b*)	.....	.....	13,662	64,235	13,662	64,235
Total	74,176	54,442	23,726	147,046	97,902	201,488

(*a*) Includes Arizona, California, Michigan, and Wisconsin.
(*b*) Includes Arizona, Michigan, and Wisconsin.

MARKETED PRODUCTION OF QUARTZ IN THE UNITED STATES, 1909-1913, IN SHORT TONS

Years.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	121,459	$131,334	14,010	$118,132	135,469	$249,466
1910	49,886	80,984	13,691	112,773	63,577	193,757
1911	77,759	70,430	10,184	84,692	87,943	155,122
1912	82,205	67,256	15,669	124,429	97,874	191,684
1913	74,176	54,442	23,726	147,046	97,902	201,488

Production in Foreign Countries.—The production of quartz in the United States and other countries for the years 1909 to 1913, inclusive, is given in the following table:

PRODUCTION OF QUARTZ IN THE PRINCIPAL PRODUCING COUNTRIES, 1909–1913, IN SHORT TONS.

Country.	1909(a).		1910(a).	
	Quantity.	Value.	Quantity.	Value.
United States	135,469	$249,466	63,577	$193,757
Canada	56,924	71,284	88,205	91,947
Germany (Saxony	.....	(b)10	.....	.....
Italy	(c)34,976	(c)43,832	(c)29,872	(c)40,057
Madagascar(f)	.....	.....	175	11,811
Sweden	11,317	14,449	13,801	15,607

Country.	1911(a)		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
United States	87,943	$155,122	97,874	$191,685	97,902	$201,488
Canada	61,496	83,864	(d)100,242	(d)195,216	(d)78,261	(d)169,842
Germany (Saxony)	.....	58	(e)	(e)	(e)	(e)
Italy	(c)39,417	(c)44,585	(c)37,416	(c)44,079	(e)	(e)
Madagascar (f)	43	4,949	(e)	(e)	(e)	(e)
Sweden	27,477	37,711	(e)	(e)	(e)	(e)

(a) Mines and Quarries: General report with statistics, pt. 4, London, except Italy, which is credited to Rivista del Servisio minerario, Rome.
(b) Includes mica and molybdenite.
(c) Includes feldspar.
(d) The mineral production of Canada, Dept. of Mines, Ottawa, 1914.
(e) Statistics not available.
(f) Includes rock crystal.

Bibliography

Ambroun, R.—Electrical Conductivity of Glass and Quartz. *Physik. Zeit.*, **14**, 112–8.

Anon.—Silica and Its Uses. *Rev. chim. ind.*, **24**, 95–9.

Brown, G. H.—Note on Load Tests Made on Magnesite, Chrome and Silica Brick. *Trans. Am. Ceram. Soc.*, **14**, 391–3.

Buttram, F.—The Glass Sands of Oklahoma. *Okla. Geol. Surv., Bull.* 10.

Calderon, S.—The Development of Silica Acid Minerals. *Bol. soc. Esp. hist. nat.*, 1908; *Zeit. Kryst. Min.*, **49**, 300–1.

Calderon, S.—Weathering and Molecular Transformations of Quartz. *Assoc. Esp. prog. cienc.*, 1908; *Zeit. Kryst Min.*, **49**, 299–300.

Callender, H. S.—The Expansion of Vitreous Silica. *Electr.*, **69**, 234–5.

Campbell, A.—Note on the Resistivities of Glass and Fused Silica at High Temperatures. *Proc. Phys. Soc. Lond.*, **25**, 336–7.

Chapman, C. M.—Importance of Testing Sands. *Eng. Record.*, **66**, 401–2.

Coupe, T. E.—Mixture for Treating Molding Sand. U. S. Patent 1064713, June 17, 1913.

Fenner, C. N.—Various Forms of Silica and Their Mutual Relations. *Jour. Wash. Acad. Sci.*, **2**, 471–80.

Frink, R. L.—Glass Sand. *Glassworker*, **31**, No. 9.

Lacroix, A.—Origin of the Transparent Quartz of Madagascar. *Compt. rend.*, **135**, 1491–6.

Lange, O.—Silica Bricks for Open-hearth Furnaces. *Stahl .u Eisen*, **32**, 1731–7.

POGUE, J. E. AND GOLDSCHMIDT, V.—Quartz from Alexander Co., N. C. *Am. Jour. Sci.*, 1913, 412–20.

POULSON, A.—Treating Foundry Sand. U. S. Patent 1052514, Feb. 11, 1913.

RASTALL, R. H.—The Mineral Composition of Some Cambridgeshire Sands and Gravels.' *Proc. Cam. Phil. Soc.*, **17**, 132–43.

SCHULZ, K.—The Mean Specific Heat of Quartz and Quartz Glass in Three Different Temperature Ranges. *Centr. Min.*, 1912, 481–91.

SEARLE, A. B.—Testing of Molding Sands. *Castings*, **10**, 183; *Eng. Mag.*, **44**, 103–7.

STONE, R. W.—Production of Sand and Gravel in 1912. *Min. Res. of U. S.*, 1912.

WERNICKE, F.—Quartzite and Silica Brick. *Stahl u. Eisen*, **33**, 235–8.

SODIUM AND SODIUM SALTS

By S. H. Salisbury, Jr.

In the sodium industry in the United States, nothing new has developed. The Virginia Electrolytic Co. and the Niagara Electrochemical Co. are the two manufacturers. The latter company uses the Castner process, caustic being the electrolyte and hydrogen a waste product. The annual production of sodium is estimated at 2000 tons. The uses are increasing. Some details as to recent practice, are given in Mineral Industry, Vols. XIX and XX. A number of factories have been started in foreign countries. One is reported at the Sognefjord, north of Bergen, Norway. The manufacture of metallic sodium, sodium peroxide, and other compounds, is to be undertaken under the title of Frederiksstad Elektrochemiske Fabriker, Frederiksstad, Norway. No imports of sodium are reported into the United States.

Nitrate of Soda

Chile.—Chile has three great productive zones, in some ways quite distinct from each other. In the extreme south, adjacent to the Strait of Magellan, is a newly developing region well suited for sheep and pastoral industries, but showing also mineral possibilities. Its natural product, however, is an abundance of woods, such as pine, where may be found one of the few districts in South America from which building material of this character can be taken. The central part of Chile possesses the famous Central valley. Here all the products of the temperate zone, and most of those of a subtropical climate, grow luxuriantly, and it is by far the most densely populated and highly cultivated part of the republic. In the north lies the third zone, which appears to be barren, sterile, and worthless, but which in reality, by reason of the nitrate found there, has been the source of much of the wealth of the country. The nitrate fields exported in 1830, the first year of the industry, only about 85,000 quintals (quintal = 220.4 lb.) of crude material; in 1911 the export amounted to over 53,000,000 quintals, and according to the International Union of American Republics, there is a visible supply of nitrate mineral, allowing for increased consumption, for at least the next 50 years.

The nitrate of saltpeter zone embraces an area in the north of Chile of about 450 miles from one end to the other. The deposits of the mineral

do not lie close to the coast, but are separated from the sea by a district varying from 3600 to 13,000 ft., in a barren and waterless plain. The climate in this region is delightful, but vegetation is absent, although nitrate forms one of the chief food ingredients of all plant life. Many well-known Chilean ports are on this strip of coast—Pisagua, Junin, Iquique, Antofagasta, Taltal, Caldera—from which the shipment of nitrate is almost the sole business. Saltpeter, or nitrate of soda, is found mixed with other substances. The beds contain four layers of material, the next lowest being that of the nitrate itself. Above this are the "chuca" on the surface, which is nothing more than the accumulation of ages; the "costra" beneath, a harder and older mass, but still somewhat worthless débris; the "caliche," the real nitrate of soda, and finally the stratum of bed-rock called "gova." To obtain the nitrate, a shaft is sunk to the gova, upon which powder is placed and exploded. The overlying mass is thrown up and the caliche containing the nitrate is scattered on the ground. This is then collected and taken to the refining works called "oficinas," for preparation into refined and almost pure nitrate of soda, ready for export. In the oficinas, machinery of the very best pattern is used, and the methods of refining are according to the best researches of industrial chemistry. The consumption of nitrate by the principal countries is as follows: Great Britain takes about 40 per cent., Germany and the United States each about 20 per cent., France about 10 per cent., and the remainder goes elsewhere, even to such far-away places as Egypt, Japan, the Hawaiian islands, and Australia. Chile derives a noticeable part of its income from the export tax on nitrate.

Of late years the Chilean industry has been subjected to the growing competition of chemical by-products, such as ammonium sulphate from gas and coke works. Ammonia is, also, obtained from the atmosphere by the Haber process at a cost so relatively small that it seems to foreshadow considerable development. The factories for the production of azotised cyanamide and synthetic saltpeter are numerous, and are increasing in number, not only in Norway, but in Austria, Italy, Spain, United States and other countries enjoying abundant water-power. It is perhaps debatable whether these artificial manures are of equal value as fertilizers to natural products, notwithstanding that some of the former include a somewhat larger proportion of nitrogen. The competition between synthetic and natural manures promise to become so keen that the Chilean Government is considering measures to protect its saltpeter trade. During the last 5 years the price of nitrate, though still permitting a prosperous business, has suffered a notable reduction.

Mr. Thomson Aikman, Jr., in his report[1] issued at the end of the year,

[1] *Min. Jour.*, Jan. 10, 1914.

gives the total production for the 12 months at about 60,050,000 quintals, against 56,200,000 quintals last year, of which 30,100,000 quintals January to June and 29,950,000 quintals July to December 1913, against 26,900,000 and 29,300,000 quintals, respectively, in 1912. Six new oficinas have commenced working during the year, and produced about 1,000,000 quintals, of which 800,000 quintals during the last 6 months. During the coming year, no new oficinas are likely to come in, although two or three old maquinas have been rebuilt, which will slightly increase their productive capacity. The total production for the coming year, should there be no restriction after January, would, therefore, appear unlikely to exceed 61,500,000 to 62,500,000 quintals under the most favorable conditions. An agreement to restrict production by about 2,050,000 quintals from July to January was come to in August by producers representing an annual production of about 41,000,000 quintals, or about two-thirds of the total production capacity. The basis adopted was that of their production from January to June—20,300,000 quintals—plus about 800,000 quintals as special allowances for several oficinas, which had increased their maquinas, and for two new oficinas, which had only produced during part of the first 6 months. The reduction therefore on their actual January to June production mounted to about 1,250,000 quintals. Up to December 31 those in the combination produced about 19,500,000 quintals, or a reduction of 800,000 quintals, leaving about 450,000 quintals to be deducted from their January output. The old oficinas outside this combination have increased their production July to December over January to June by about 400,000 quintals, and four new oficinas not working during the first 6 months have produced about 250,000 quintals. Endeavors are now being made to get a unanimous agreement among all producers to restrict production again during part of next year, should it be considered advisable, although it is probable that this will be unnecessary, if the consumption next spring comes up to expectations. It has also been suggested that a scheme for the total centralization of sales be studied, but the chances of such being generally accepted appear remote. The scarcity of labor continued throughout the year, necessitating higher wages, and the cost of production, except in a few exceptional cases, has risen about 2d. to 4d. per quintal. The average selling prices obtained by producers have in most cases, however, been considerably higher than last year, when so much had been sold ahead before the advance in values. The fall in steamer freights of about 12s. 6d. per ton as compared with this date last year is a favorable feature for producers, as it cheapens the cost of delivery in the consuming markets by this amount.

As regards consumption, 1913 has been somewhat disappointing,

as against an increase of over 200,000 tons in 1912 a net increase of only 12,000 is shown for last year. Messrs. W. Montgomery & Co. give the following details for the chief consuming centers:

In Europe there was a decreased consumption of 84,000 tons as compared with 1912. This loss occurred in the first 6 months of the year, as was recorded in our report of June 30 last, indeed the loss at that date was greater by about 33,000 tons; thus to this extent has consumption in Europe recovered during the past 6 months. The American deliveries, at 261,000 against 238,000, show a gain of 23,000 tons for the past 6 months, which, added to 73,000 tons increase in the first half of the year, makes, for the 12 months, a gain of 123,000 tons. Other countries, excluding Egypt, show a decrease of 4000 tons, the figures being 88,000 against 92,000 tons. Thus the world's consumption for the 12 months shows a net gain of 12,000 tons, the figures being 2,520,000 against 2,508,000 tons. An analysis of the European figures shows that Germany accounted for 814,000 tons against 888,000, a decrease of 74,000 tons, or 8.3 per cent. Belgium, with 308,000 against 295,000, increased 13,000 tons, a gain of 4.4 per cent. France, at 312,000 against 349,000, shows a decrease of 37,000 tons, or 10.6 per cent., while Holland disposed of 162,000 against 174,000, a decrease of 12,000 tons, or 6.9 per cent. Italian and Austrian ports accounted for 55,300 against 50,000, an increase of 5300 tons, or 16 per cent. In the United Kingdom a decrease of 6000 tons, or 4.6 per cent., is recorded, the figures being 124,000 against 130,000 tons. In general, confidence is expressed that the increasing demands of the world will take care of any increases in supplies of nitrogenous fertilizers which were derived last year as to 55 per cent. from nitrate of soda, as to 40 per cent. from sulphate of ammonia, and as to 5 per cent. from synthetic nitrate.

The following are Mr. Aikman's statistics for the past 4 years (in tons):

	1910.	1911.	1912.	1913.
Exports to Europe and Egypt	1,658,000	1,840,000	1,887,000	1,968,000
Exports to United States, etc	648,000	578,000	571,000	687,000
Deliveries in Europe and Egypt	1,677,000	1,720,000	1,930,000	1,813,000
Deliveries in United States, etc. (on basis of shipments 2 months previous)	600,000	640,000	573,000	695,000
Visible supply for Europe and Egypt at Dec. 31	967,000	1,058,000	975,000	1,070,000
Visible supply for U. S., etc. (on basis of 2 months' shipments), at Dec. 31	162,000	96,000	88,000	76,000
Production in Chile, Jan. to June	1,198,000	1,229,000	1,219,000	1,363,000
Production in Chile, July to December	1,236,000	1,258,000	1,327,000	1,357,000
Average spot price in Europe per cwt., cost and freight terms	8/5.5	9/–	10/1	10/3
Stocks in Chile at Dec. 31, estimated at	450,000	460,000	490,000	500,000

The following table shows the shipments and consumption of nitrate of soda for the last 13 years.

NITRATE OF SODA STATISTICS. (a)
(In tons of 2240 lb.)

Year.	Shipments from South America.	Consumed in Europe.	Consumed in United States.	Consumed in World.	Stocks in Europe.	Visible Supply at Close of Year.
1900	1,429,000	1,126,000	175,000	1,324,000	221,000	794,000
1901	1,238,000	1,154,000	192,000	1,364,000	243,000	617,000
1902	1,360,000	1,028,000	214,000	1,259,000	263,000	660,000
1903	1,435,000	1,127,000	265,000	1,412,000	155,000	654,000
1904	1,476,000	1,131,000	275,000	1,447,000	162,000	672,000
1905	1,623,000	1,190,000	308,000	1,547,000	183,000	674,000
1906	1,700,000	1,243,000	355,000	1,636,000	190,000	733,000
1907	1,626,000	1,252,000	350,000	1,658,000	202,000	695,000
1908	2,017,000	1,378,000	309,000	1,732,000	402,000	928,000
1909	2,100,000	1,465,000	407,000	1,938,000	337,000	999,000
1910	2,300,000	1,651,000	501,000	2,241,000	310,000	969,000
1911	2,412,000	1,696,000	550,000	2,355,000	479,000	1,058,000
1912	2,478,000	1,908,000	481,000	2,504,000	310,000	1,004,000

(a) Statistics of W. Montgomery & Co., London.

Practically no niter is produced in the United States although a few deposits are known. All the nitrate consumed in this country is imported from Chile, the amounts being shown in the following table:

IMPORTS OF SODIUM NITRATE INTO THE UNITED STATES. (a)
(In tons of 2240 lb.)

Year.	Quantity.	Value.	Value per ton.	Year.	Quantity.	Value.	Value per ton.
1902	205,245	$5,996,205	$29.21	1908	310,713	$11,385,393	$36.64
1903	272,947	8,700,806	31.88	1909	422,593	13,281,629	31.43
1904	228,012	9,333,613	40.93	1910	529,172	16,601,328	31.37
1905	321,231	11,206,548	34.89	1911	544,878	16,814,256	30.86
1906	372,222	14,115,206	37.92	1912	486,352	16,668,404	34.25
1907	364,610	14,844,675	40.71	1913	625,862	21,630,811	34.56

(a) As reported by the Bureau of Statistics, Department of Commerce. The figures of value appear to be doubtful, especially with respect to the earlier years.

Recent Discoveries of Niter, Peru.—Investigations of supposed nitrate fields commenced in 1912, in the Department of Arequipa, were abandoned early in 1913, as the region examined did not cover nitrate of economic value. Mention has recently been made of a discovery of 500 acres of 9 per cent. nitrate ground in the Department of Libertad, but no data as to the tonnage are obtainable.

Montana.—Last year R. W. Richards, of the United States Geological Survey, visited a niter deposit on Camp Creek, near Melrose, Mont., said to have been discovered by F. C. Moore, of Melrose. While the deposit may not prove of economic importance, it is interesting in that it affords another example of a nitrate deposit in a region having a fairly abundant rainfall.

The value of the deposit cannot be safely estimated from the data which have been collected. Further exploration is needed to determine whether or not the potash and soda nitrates are included in the limestone back from the outcrop.

The salt consists of a snowy white to slightly yellowish mass of needle-like crystals. Analyses show the following: calcium sulphate, 13.94 per cent.; sodium sulphate, 3.30 per cent.; sodium chloride, 20.42 per cent.; sodium nitrate, 21.77 per cent.; niter, 39.48 per cent. and nitrogen pentoxide, 1.19 per cent. As the average soluble portion of the samples collected by Mr. Richards is only about 1 to 5 per cent., it appears that about 35 tons of rock would have to be treated to obtain 1 ton of the crude salts. This quantity if refined would yield about 340 lb. of soda niter and about 790 lb. of potash niter, the former being at present worth about $24 and the latter about $41, making a gross yield of about $1.80 per ton of rock treated. Better returns might be obtained by treating the loose rock fragments which lie at the base of the cliffs, but such material is very meager in amount.

IMPORTS OF SODIUM SALTS. (*a*)
(In tons of 2000 lb.)

	1909.		1910.		1911.		1912.		1913.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Arseniate....	125.4	$7,106	242.3	$14,368	84.2	$5,199	178.3	$11,195	634.0	$55,941
Ash.....	2,220	48,674	2,495.0	55,262	1939.1	43,365	1452.7	33,459	1550.4	35,461
Bicarbonate...	60.9	4,821	73.2	4,472	42.6	2,634	55.0	3,193	40.3	2,238
Bichromate and Chromate....	1,206	97,661	1,332.1	101,687	.....	1	.....	.....	.....	3
Caustic.....	391	24,742	519.4	33,882	1,492.1	73,968	465.3	28,937	335.7	25,364
Carbonate (Crystal).....	84	3,464	69.9	2,569	152.6	4,235	177.3	5,616	84.6	2,928
Chlorate.....	.....	12	.....	.....	.....	2	.....	22	.....	10
Chloride (Salt).	145,678	437,892	138,376.2	374,420	141,227.8	390,043	145,041	379,539	125,428	356,911
Hyposulphite..	6	312	22.3	626	14.7	612	4.3	277	3.6	228
Nitrate.....	353,558	12,583,417	542,334.0	16,548,036	546,394.6	17,101,155	481,786	15,427,904	656,672	20,713,375
Nitrite.....	76	7,258	566.3	52,237	238.8	21,205	487.3	47,399	6,34.8	57,595
Phosphate.....	25	707	31.0	1,045	22	750	.....	.....	.....	14
Prussiate.....	981	123,880	649.9	76,648	598	66,971	823.2	90,654	943.7	118,475
Sal Soda.....	252	3,231	241.1	4,630	107.2	1,512	126.8	2,020	64.0	1,010
Salt Cake.....	18	767	3,928.0	40,640	11,398.1	121,218	659	8,394	.....	.....
Silicate.....	509	8,578	599.5	12,994	617.3	11,713	466.6	8,870	516.1	9,400
Sulphide.....	267	7,764	298.3	9,086	228.0	4,751	361.5	10,456	475.8	12,360
Sulphite.....	235.4	10,150	125.5	4,082	493.7	14,810	177.1	4,860	13.6	400
Sulphate.....	.....	.....	.....	.....	.....	.....	.....	.....	588.4	10,456

(*a*) For fiscal years ending June 30.

SODA

Sodium Products in China.[1]—Imports of soda ash and other sodium products into China for soap making and other purposes have reached a

[1] Consul General George E. Anderson, Hongkong, *Daily Consular and Trade Reports.*

considerable volume. The imports of various forms of soda, included in the Chinese customs returns under the general term of soda but consisting mostly of soda ash, amounted in 1912 to about 25,290 short tons, valued at $677,757 gold, as compared with 24,190 short tons, valued at $678,677 gold in 1911.

The product as imported in this part of the world comes almost entirely from Great Britain. Soda produced by the ammonia process is that usually imported. About nine-tenths of the total imports enter China direct from Great Britain, and other quantities are imported through Hongkong. Hongkong firms handle a considerable part of that going direct to Chinese ports generally, though the cargoes are shipped direct. Tientsin takes about 20 per cent. of the total imports, Shanghai about 10 per cent., and Canton and Hankow about 8 per cent. each. The rest of the product is distributed over the country in scattering amounts.

Recently Hongkong firms have been dealing in soda ash 58 per cent. standard, made by the ammonia process (Bruner-Mond) on the basis of $17.76 per long ton f. o. b. London in casks of 10 to 12 cwt.; $18.49 per ton in casks of 5 to 6 cwt.; and $19.47 and $21.29 per ton, respectively, for casks of 3 cwt. and 1 cwt. Hardwood casks are charged for at the rate of $2.80 per ton extra.

SALT

The production of salt in the United States is shown in the following table:

PRODUCTION OF SALT IN THE UNITED STATES. (a)

(In barrels of 280 lb.)

Year.	California.	Illinois.	Kansas.	Louisiana.	Michigan. (c)	Nevada.	New York. (c)	Ohio, W. Virginia and Pa. (b)	Utah.	Other States.	Total Barrels.
1902	682,680	90,009	2,158,486	399,163	8,131,781	14,829	8,523,389	2,318,579	417,501	1,112,824	20,566,661
1903	629,701	(d)	1,555,934	568,936	4,297,542	(d)	8,170,648	3,043,135	212,995	489,238	23,849,221
1904	821,557	(d)	2,161,819	1,095,850	5,425,904	(d)	8,600,656	3,030,829	253,829	639,558	18,968,089
1905	664,099	(d)	2,098,585	1,055,186	9,492,173	(d)	8,359,121	2,728,709	177,342	1,390,907	22,030,002
1906	806,788	(d)	2,198,837	1,179,528	9,936,802	11,249	8,978,630	3,436,840	262,212	1,361,494	25,966,122
1907	626,693	(d)	2,667,459	1,157,621	10,786,630	6,459	9,657,543	4,007,390	345,557	464,143	28,207,743
1908	899,028	(d)	2,588,814	947,129	10,194,279	9,714	9,005,311	3,572,635	242,678	1,291,042	29,719,493
1909	886,564	(d)	2,769,849	(d)	9,966,744	16,107	9,880,618	3,835,267	246,935	2,505,562	28,754,630
1910	937,514	(d)	2,811,448	1,372,248	9,452,022	17,535	10,270,272	3,829,475	249,850	1,365,292	30,305,656
1911	1,086,163	(d)	2,159,859	(d)	10,320,074	12,856	10,082,656	4,485,886	272,420	2,776,910	31,183,968
1912	1,090,000	(d)	2,573,626	(d)	10,946,739	12,536	10,502,214	5,408 300	283,293	2,508,100	33,324,808
1913	1,458,621	.....	.....	.....	11,640,633	.....	10,819,521	.....	.....	.....	.....

(a) Statistics of the U. S. Geological Survey except for New York since 1905, which are from reports of the State Geologist. (b) The production of Pennsylvania since 1905 is included in "Other States." (c) Includes brine used in manufacture of alkali. (d) Included in "Other States."

CONSUMPTION OF SALT IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Production.		Imports.		Exports.		Consumption.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
1899	2,759,206	6,867,467	189,051	579,682	12,600	86,465	2,935,657	7,360,684
1900	2,921,708	6,944,603	199,909	634,307	7,511	65,410	3,114,106	7,513,500
1901	2,879,332	6,617,449	201,733	676,324	9,433	86,414	3,071,632	7,207,359
1902	3,338,892	5,668,636	184,764	647,554	5,094	55,432	3,518,562	6,260,758
1903	2,655,532	5,286,988	165,981	495,948	12,750	95,570	2,808,763	5,687,366
1904	3,084,200	6,021,222	166,140	467,754	13,964	113,625	3,236,376	6,375,351
1905	3,635,257	6,095,922	161,159	492,189	34,238	239,223	3,762,178	6,348,888
1906	3,944,133	6,658,350	170,505	502,583	33,988	274,627	4,080,650	6,886,306
1907	4,160,729	7,439,551	153,435	452,227	30,802	232,895	4,283,362	7,658,883
1908	4,024,345	7,486,894	156,609	440,484	26,627	202,338	4,154,327	7,725,040
1909	4,215,070	8,343,831	158,487	447,983	40,158	269,273	4,333,397	8 522 541
1910	4,242,792	7,900,344	142,549	388,015	49,013	320,926	4,336,328	7,967,433
1911	4,365,756	8,345,692	137,759	378,083	48,873	335,285	4,454,642	8,397,490
1912	4,665,473	9,402,772	136,391	361,664	62,410	418,525	4,739,454	9,345,911
1913	.....	.....	150,601	416,375	70,289	515,194	.....	.....

California.—(By F. McN. Hamilton).—The California production for 1913 is as follows:

	Tons.	
Alameda County[1]	129,318	$233,388
Los Angeles	10,000	40,000
Inyo	13,500	54,000
Modoc	40	720
San Bernardino	3,049	10,573
San Diego	20,500	51,750
San Mateo	28,000	72,250
Total	204,207	$462,681

[1] Estimated.

The above figures are final, with the exception of those given for Alameda County. Two producing companies in that county have not yet reported and the above estimate was made by using the 1912 figures in those cases. There is no indication that either company's output decreased during the past year so that it is reasonable to believe that the final returns will show a grand total equal, if not slightly exceeding the one given above.

The salt industry for 1913 shows but little change as compared with the previous year, either in amount of crude salt produced or in the price obtainable for the product. As shown by the above table the output amounted to 204,207 tons valued at $462,681 as compared with 185,721 tons produced in 1912 worth $383,370. The average value per ton was a little better than $2 for each year. Alameda and San Diego Counties show a slight increase and San Mateo a slight decrease for the year. The decrease in San Mateo output being directly attributable to floods resulting from the storms which occurred during the last months of the year. From the present outlook the damage done as a result of storms and high water will be still more apparent in the returns for 1914. The salt production of San Bernardino County is derived from deposits of rock salt which

are worked by means of quarrying with a steam shovel. All other salt produced in the state results from the evaporation of saline waters of bays, lakes and springs. A small amount of valuable medicinal salts was produced during the year in Mono and Tehama Counties, by evaporation in the first case from the waters of Mono Lake, and in the second, from the waters of a mineral spring, but as the material was not sold during 1913 the figures have not been used in this report.

The plant in Inyo County has but recently been installed and is using the solar process.

Louisiana.—Louisiana is also an important producer of rock salt, in which it ranks second among the States. The salt mines underlie so-called islands, which are really mounds rising above the marsh lands along the Gulf shore in Iberia Parish. The Petite Anse mines, on Avery Island, were operated during the Civil War, having been developed in a small way in 1862. These mines were flooded twice, and a new shaft was sunk in 1899. Mining on Weeks Island began in 1902. In the value of the total production of salt, which includes the product evaporated from brine, Louisiana ranks sixth among the States.

Michigan (By R. C. Allen).—Partly unedited returns from the various operating companies total 11,640,633 bbl. valued at $3,425,628. These figures include evaporated, rock and brine salt, bromine and calcium chloride. Reports have been received from all of the active firms, but there are discrepancies in some of the reports which to date have not been fully explained, and doubtless further information will modify the above figures to a greater or less extent. Probably the greatest change will be in value as some of the figures for individual companies apparently represent gross instead of net values, the cost of the container not being deducted.

According to the provisional figures the production for 1913 shows an increase in output of about 650,000 barrels over 1912, and an increase in value of over $450,000. Most of the companies show a slight increase in production, and also a slight increase in the value per barrel for the ordinary grades of salt. Five of the largest companies show large increases, which accounts for three-fourths of the total increase in both production and value.

Thirty years ago the bulk of the salt produced in Michigan came from the Saginaw valley where salt blocks were operated in connection with the lumber mills, utilizing exhaust steam, and waste from the saw mills for fuel. Hundreds of salt wells were scattered along Saginaw river from St. Charles through Saginaw to Bay City, drawing natural brine from the Marshall sandstone. With the decline of the lumbering industry the production of salt in the Saginaw valley has declined to small proportions.

At present the chief seats of the industry are along the Detroit and St. Clair rivers and at Ludington and Manistee where artificial brines from rock-salt beds of the Salina are utilized. The Detroit-St. Clair river district is the most important as it produced over two-thirds of the entire output of the state in 1913. In the Manistee and Ludington districts much of the salt is manufactured in connection with lumber mills, or other industrial plants, utilizing exhaust steam and the waste fuel of the lumber mills.

In the Detroit-St. Clair river district salt blocks are operated independently of other industries and use coal as a fuel, which is obtained very cheaply by water. Large quantities of brine are used in the manufacture of soda ash in the vicinity of Detroit. Rock salt is mined in Oakwood, a small suburb of Detroit. Rock salt also occurs in Alpena and Presque Isle counties, and owing to the proximity of an abundance of high calcium limestone conditions are favorable for the development of chemical industries.

New York (By D. H. Newland).—The output of rock and brine salt in 1913 amounted to 10,819,521 bbl. a slightly larger quantity than was reported in the preceding year. The output had a value of $2,856,-664, or an average of 26.4 cents a barrel. There were approximately 30 plants in operation, distributed among six counties—Livingston, Onondaga, Schuyler, Wyoming, Tompkins and Genesee in the order of rank as producers.

The sources of salt production in NewYork are natural brines and beds of rock salt. Natural brines have been found in various sections and different rock formations, but the single occurrence of present importance is in the vicinity of Syracuse on the old Onondaga Salt Springs Reservation, where the brines are found in loose gravels and sands that are supposed to be of glacial origin. The sands and gravels fill a depression or basin in Salina shales and the derivation of the brine is somewhat uncertain as there is no rock salt in the immediate vicinity, the nearest beds being 20 miles south of Syracuse at Tully. The brines are pumped from depths of 200–400 ft. and contain about 15–17 per cent. of saline constituents.

The rock salt occurs in the Salina shale formation which outcrops across the State from Albany County to the Niagara river, but the productive section is limited to the central and western area. On account of its ready solubility, the salt is rarely encountered at depths less than 800 or 1000 ft. from the surface. As the Salina formation has a dip to the south of 50 ft. or so to the mile, the mines and wells are situated some distance south of the projected line of outcrop which lies about on the 43d parallel of latitude. To the southward, the beds are found at pro-

portionately increasing depths and extend as far as the southern tier of counties. They have been penetrated in gas wells in Cattaraugus and Allegany Counties at depths exceeding 3000 ft. The thickness of the salt ranges from a few feet up to 100 ft. or more.

There are two active salt mines in the State, the one at Retsof owned by the Retsof Salt Co. and the other at Cuylerville belonging to the Sterling Salt Co. Both are worked through vertical shafts about 1100 ft. deep. In the mine of the Sterling Salt Co. the workings are laid out in panels, with the main galleries running east and west and the headings driven to the north so as to take advantage of the slight dip in tramming to the main haulage ways. Of the 20 ft. or so of salt, only about 12 ft. are actually mined, the remained being left in the roof and floor. The breast of salt is worked in two benches. The rooms are 30 ft. wide and are separated by pillars of equal size. There is no timbering required in the workings and of course no drainage to provide for. The salt is drilled by rotary auger drills driven by compressed air. The holes are placed with a view to making the greatest proportion possible of lump salt; they are charged lightly with a low-grade dynamite. The charging and blasting is done by a separate crew, one man for each pair of drillers. The broken salt is loaded into 3-ton cars which are run down to the haulage ways and thence drawn to the shafts. The preparation of the salt on the surface consists in crushing and screening. A portion of the output is sold uncrushed for cattle salt. The screened sizes find use in curing of hides, refrigeration, manufacture of oleomargarine, fish-salting and in various industries where purity is not absolutely essential.

The manufacture of brine salt is carried on either by the solar method or by artificial evaporation. The solar process is only employed with the natural brines near Syracuse. The product varies from year to year with the character of the season. It is sold in seven sizes, the finest passing through an 8-mesh screen and the coarsest about the size of hickory nuts. It is used practically for the same purposes as rock salt. The Onondaga Coarse Salt Association markets the product of the evaporating plants which are operated by about twenty firms or individuals.

Artificial brines with from 23 to 25 per cent. of sodium chloride are obtained by sinking wells into the rock-salt beds through which fresh water is run to be pumped back when saturated. The wells range from 1000 to 2250 ft. deep. Evaporation is effected by the grainer, open-pan or vacuum-pan process. Some plants make use of only one method, but others and perhaps the greater number combine the grainer with vacuum pans or open pans. All of the commercial grades of evaporated salt are made, inclusive of common fine, common coarse, table and dairy and packers salt.

The statistics of salt for the year 1913, as well as those given in previous volumes of THE MINERAL INDUSTRY, include a considerable quantity of salt in brine that is consumed in alkali manufacture. This salt is not evaporated and consequently bears a very low valuation, which brings the average for the whole product down to a point well below the actual market prices of salt. The actual selling prices of evaporated salt ranged in 1913 from 30 cents a barrel for solar to about 60 cents for the table and dairy grades.

SALT PRODUCTION BY GRADES.

Grade.	Barrels.	Value.
Common fine	1,490,957	$ 583,757
Common coarse	111,057	45,942
Table and dairy	1,266,864	789,857
Coarse solar	436,800	131,040
Packers	107,293	51,895
Other grades[1]	7,406,550	1,254,173
Total	10,819,521	$2,856,664

PRODUCTION OF SALT IN NEW YORK SINCE 1888.

Year.	Barrels.	Value.	Year.	Barrels.	Value.
1888	2,318,483	$1,130,409	1901	7,286,320	$2,089,834
1889	2,273,007	1,136,503	1902	8,523,389	1,938,539
1890	2,532,036	1,266,018	1903	8,170,648	2,007,807
1891	2,839,544	1,340,036	1904	8,724,768	2,102,748
1892	3,472,073	1,662,816	1905	8,575,649	2,303,067
1893	5,662,074	1,870,084	1906	9,013,993	2,131,650
1894	6,270,588	1,999,146	1907	9,657,543	2,449,178
1895	6,832,331	1,943,398	1908	9,005,311	2,136,736
1896	6,069,040	1,896,681	1909	9,880,618	2,298,652
1897	6,805,854	1,948,759	1910	10,270,273	2,258,292
1898	6,791,798	2,369,323	1911	10,082,656	2,191,485
1899	7,489,105	2,540,426	1912	10,502,214	2,597,260
1900	7,897,071	2,171,418	1913	10,819,521	2,856,664

Ohio.—The production of Ohio ranks third of the States, and in 1911 was 4,302,507 bbl. (602,351 tons), valued at $1,100,453, and in 1912 5,269,179 bbl. (737,685 tons), valued $1,364,136. The production in 1910 was reported by the United States Geological Survey as 3,673,850 bbl. valued at $951,963. The principal district is the southeastern, with Pomeroy as the center. The formation into which the wells are drilled is near the top of the "Conemaugh" (formerly Lower Barren Coal Measures). The production of the wells has been maintained by increasing their depths, until now both in Ohio and West Virginia brine is being pumped from depths of 1100 to 1350 ft. The relatively large quantities of bromides in these brines is probably due to the salt-bearing rocks being deposited very near the shore line and being part of a landlocked sea. The other district producing salt in Ohio, namely, the northeastern, procures its brines from the Monroe formation of the Silurian.

[1] Includes rock salt, salt in brine used for alkali manufacture and small amounts of brine salt for which the uses were not specified in the returns.

According to Mr. J. A. Bownocker, salt is made in Ohio in only two localities; at Pomeroy and vicinity on the Ohio River, where a salt brine is used, and in northern Ohio near Akron, where rock salt abounds and is dissolved and later evaporated for salt. While at this time statistics are not available it is probable that the situation is about the same as in 1912.

Pennsylvania (By Richard R. Hice).—While in the past there has been a large production of salt from Pennsylvania, the same being derived from the brines obtained from deep wells, yet in the last few years the production has been confined to a small output in Alleghany City (Pittsburgh N. S.), and, therefore, it is impossible to give the figures of production without disclosing the individual output. The products consist of table, common fine, common coarse, and dairy salt, with some production of calcium chloride and bromine.

One of the difficulties at the plants in Alleghany is with the casing of their wells. The casing has quite a short life, and seems to be much shorter during the last few years than earlier. This has been, of course, charged to the corrosive action of the brines, but it is altogether possible that much of the present difficulty is due to the electrolysis, which is known at one point not far distant to reduce the life of the casing to about one year, the casing being destroyed at the salt-water horizon.

There are in the State a great many wells producing brines which carry in many cases a good percentage of bromides, and it seems remarkable that the salt industry has been allowed to decline in the way it has. It is certainly not in a very prosperous condition.

Texas.—Mr. Wm. B. Phillips reports the output for Texas as 49,744 tons valued at $278,008. This was produced at three plants.

West Virginia.—The output of West Virginia as estimated by J. Q. Dickinson & Co., of Malden is 125,000 bbl. valued at $125,000. The output was somewhat reduced on account of the heavy flood of the spring of 1913 on the Ohio River.

Foreign Countries

Argentina[1].—The salt consumed in this district, which covers the northern half of Argentina, is practically all imported, coming largely from the United Kingdom, Germany, and Spain. The two classes of salt known on the local market are sea salt, commonly called Cadiz, and fine salt, which is not graded by quality but by origin and packing. The annual consumption may be stated approximately at 900,000 lb. of sea salt, 160,000 lb. of fine English salt in glass, 600,000 lb. of fine English in barrels, 250,000 lb. of fine German in barrels, 50,000 lb. fine in pack-

[1] Consul Robert T. Crane, Rosario, *Daily Consular and Trade Reports.*

ages, and 50,000 lb. fine in bags. The average wholesale prices are as follows:

Cadiz, 75 cents per 100 lb.; fine English in glass, per dozen jars holding about 2 lb. each, $1.60; fine English per bbl. of about 100 lb., $1.90; fine German per bbl. of about 133 lb., $1.80; fine German in packages, per case of about 55 lb., $1.36; fine German, per bag of about 110 lb., $1.20.

The American salt barrel of 280 lb. net would apparently be received with favor, and the large-sized bag would also be acceptable. All fine salt for this market requires special preparation against dampness. The very best brands on the market find ready sale, but there is a demand for all qualities.

British Columbia.—A press despatch from Prince Rupert, B. C., to the Vancouver Daily Province, of recent date, follows: "An extensive bed of salt has been discovered at Kwinitsa (Mile 45, on Grand Trunk Pacific railway) on the Skeena river. For some time it has been known that salt existed at this place, and tests were made by F. H. Mobley, D. Whiteford, and others. A few days ago a solid salt-bed was struck by drilling. So far five holes have been drilled at considerable distance apart, some more than a mile from others, and all have struck salt, at depths varying from 50 to 250 ft. At the property Moberly & Whiteford have an up-to-date drilling outfit and have erected a small testing plant, consisting of three evaporating pans. Up to the present about 8 tons of salt has been secured from the deposits. The most thorough tests show that it is absolutely pure and of the best quality. The principal salt wells of Canada are situated in Western Ontario. On account of the long rail haul most of the salt used in British Columbia is imported from California. The presence of valuable salt beds in the immediate vicinity of this city is, therefore, of great importance, especially in connection with the fishing industry on the coast."

China.—Salt is produced in the province of Szechuan, China, amounting to 300,000 tons per year, while the output of the districts tributary to the T'o river is 600,000 tons.

Turkey.—Asia Minor is provided with an exceptionally large number of salt deposits, which are worked for the state under the salt monopoly. The revenues from salt are part of the guarantee for the public debt, and, therefore, the mining, refining and distribution are carried out by by the administration of the debt.

Venezuela[1]—Minister Preston McGoodwin, at Caracas, Venezuela, reports that a concession for the operation of the Venezuelan salt beds for two years from January 1, 1914, was awarded on December 29, 1913,

[1] *Daily Consular and Trade Report*

to the Compania Anonima de Navegacion Fluvial y Costanera de Venezuela, for 8,000,000 bolivars ($1,544,000).

Bibliography

Fry, Wm. H.—Rock Salt in British Columbia. *Oil, Paint, & Drug Reporter*, May 19, 1913.

Riemanm.—Die deutschen Saltzlagerstatten, ihr Vorkommen, ihre Entstehung, und die Verwertung ihrer Produkte in Industrie und Landwirtschaft.

Riemanm.—Manufacture of Salt by Solar Evaporation Discontinued. *Min. Eng. World*, Jan. 11, 1913.

———. Mining Salt with Steam Shovel in California. *Excav. Eng.*, April, 1913.

———. Salt in British Columbia. *Min. Eng. World*, Oct. 25, 1913.

———. Salt Manufacture at Carrickfergus. *Jour. Soc. Chem. Ind.*, Nov. 15, 1913.

———. Sections of Two Michigan Salt Wells. *Journ. Geol.*, May–June, 1913.

SULPHUR, PYRITE AND SULPHURIC ACID

By Samuel H. Salisbury, Jr.

The world's supply of sulphur during 1913 was, as has been the case for several years past, obtained chiefly from Louisiana and Sicily. The total shipments from Sicily in 1913 were 434,473 metric tons as compared with 447,830 metric tons in 1912 and 456,225 tons in 1911. The decrease in shipments coupled with a decrease of nearly 100,000 tons in Sicilian stocks during 1913 shows that the industry suffered considerably in 1913.

The imports of crude sulphur into the United States during 1913 were 14,636 long tons, valued at $278,056, a decrease from 1912 when the imports were 26,885 tons valued at $494,778. The exports of crude sulphur continued to increase in 1913 being 89,736 long tons valued at $1,599,761 as compared with 57,736 tons worth $1,076,414 in 1912, an increase of nearly 55 per cent.

In the United States, while there was a largely increased export trade, the consumption remained stationary and the domestic production was decreased by nearly one-half because the largest producer, the Union Sulphur Co., in Calcasieu parish, Louisiana, owing to its large stock, which was prepared preliminary to an active extension of its foreign trade, kept its production as low as possible during 1913. The amount of sulphur produced in the Texas district was comparatively small and had no effect on the total production, which, it is safe to say, was 40 to 50 per cent. below that of 1912.[1]

Markets.—Prices in the United States were steady throughout 1913, quotations being $22 per ton at New York and $22.50 at by-ports. The tendency of prices of Sicilian sulphur is to rise due to local conditions but up to the present the prices have been kept down owing to the competition of the American sulphur and this will probably be the case for some time to come. The amount of Japanese sulphur coming into the Pacific ports was about the same as in 1912, exportation from that source not having increased. The demand for sulphur in Europe was somewhat greater in 1913 than in 1912, as is shown by the increased exports of American sulphur, although Sicilian shipments decreased somewhat.

The output of the Consorzio for 1913 is estimated at 349,602 tons while the shipments are placed at 434,473 tons, the stocks thus decreasing by about 100,000 tons over those of 1912. Several Sicilian mines closed on account of fire and explosions remained inactive and others reached such a depth that their exploitation is becoming unprofitable at present prices.

[1] *Eng. Min. Jour.*, Jan. 17, 1914.

The market will probably remain normal during 1914, the decreased Sicilian production being offset by increased American production.

It is probable, however, that lower prices of sulphur will not obtain since the world's consumption is steadily on the increase, while the principal producers, namely the Sicilian Consorzio and the American companies, will probably maintain values.

Apparently a new competitor has entered the field—the Freeport Sulphur Co., of Bryan Heights, Texas, which will endeavor to secure a share of the consumption, but will probably not affect present prices.

SULPHUR IMPORTS AND EXPORTS OF THE UNITED STATES.
(In tons of 2240 lb.)

Kind.	1908.		1909.		1910.		1911.		1912.		1913.	
	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.
Imports:												
Crude. ..	20,118	$318,577	26,914	$458,954	28,647	$495,988	24,250	$436,725	26,885	$494,778	15,122	$286,209
Flowers..	793	22,562	770	23,084	912	30,180	3,891	83,491	1,310	39,129	5,899	115,574
Refined..	692	17,227	966	26,021	985	25,869	986	24,906	1,665	40,933	1,234	29,091
Precipitated....	30	4,012	58	7,565	47	6,489	68	8,643	66	9,137	350	17,690
Total imports...	21,633	$362,378	28,708	$515,624	30,544	$552,037	29,127	545,122	29,860	$574,837	22,605	$448,564
Exports.	27,894	561,534	37,152	736,928	30,742	552,941	28,103	545,420	57,736	1,076,414	89,221	1,599,761

CONSUMPTION OF SULPHUR IN THE UNITED STATES.
(In tons of 2240 lb.)

Source.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Sulphur—Domestic production.	294,000	307,806	307,761	303,000	259,699	206,200	787,663	311,590
Imports.....	64,646	20,318	20,118	26,914	28,647	24,250	26,885	14,636
Total.....	358,646	328,124	327,879	329,914	288,346	230,450	814,548	326,226
Exports.....	14,419	35,925	27,894	37,152	30,742	28,103	57,736	89,221
Consumption.	344,227	292,199	299,985	292,762	257,604	202,347	756,812	237,005
(a) Sulphur contents....	337,342	286,355	293,985	286,906	252,452	198,300	741,676	232,265
Pyrites—Domestic production..	225,045	261,871	206,471	210,000	223,700	299,904	337,243	341,338
Imports.....	533,346	627,985	668,115	692,385	806,590	1,001,453	964,478	848,674
Total.....	758,391	889,856	874,587	902,385	1,030,290	1,301,357	1,292,213	1,190,012
Exports.....	.....	.....	.....	.....	.....	.....	.....	.....
Consumption.	758,391	889,856	874,587	902,385	1,030,290	1,262,540	1,292,213	1,190,012
(b) Sulphur in domestic....	99,020	115,223	90,847	92,400	98,428	131,958	148,387	150,189
(c) Sulphur in foreign.....	250,673	295,153	314,015	325,420	379,097	470,683	453,305	398,898
Total sulphur content....	349,693	410,376	404,862	417,820	477,525	602,641	601,692	549,087
Grand total sulphur consumption. (e)	687,035	(d)696,731	(d)698,847	704,726	729,977	800,941	1,343,368	781,352

(a) Includes crude and refined sulphur. Sulphur content of crude is computed at 98 per cent. (b) Computed at 44 per cent. (c) Computed at 47 per cent. (d) This figure is in excess of the true consumption as a large percentage of the domestic output of sulphur was stored. (e) The above totals are of course exclusive of by-product sulphur.

The table of consumption is retained, but the figures are only for comparison with previous years. Actual consumption cannot be calculated because stocks of sulphur are not known, and the imports of pyrite used for the sulphur content are probably low.

Sulphur Mining in the United States

Louisiana.[1]—The Union Sulphur Co. continues to be the dominant factor in the production of sulphur, the developments at the Bryan Heights dome in Texas not having come up to expectations. This company owing to its large stock of sulphur accumulated in 1912 prepared as a preliminary to extending its export trade, kept its production in Louisiana as low as practicable in 1913 and at the end of the year was pumping from only four wells. The production of some of these wells have been remarkable, having exceeded all previous records in total production. The production of the Union Sulphur Co. in 1913 was approximately 480,000 tons as against 800,000 tons in 1912. The company as heretofore maintained a considerable stock at Sulphur, Louisiana. The Company's domestic business was about the same as in 1912 but it increased its sales in Europe where it has four distributing stations, viz: Rotterdam, Harburg, Marseilles and Cette. The company also shipped some sulphur during 1913 to Mexico where the local mines were not equal to the demand.

A description of the Louisiana Sulphur deposits is given in Mineral Industry, Vol. XVIII, p. 644. The Frasch process for removing sulphur as applied in the Louisiana field is described in Mineral Industry, Vol. V, p. 514.

Texas.—The only sulphur field in Texas is that of the Freeport Sulphur Co. near the mouth of the Brazos river, about 40 miles from Galveston. This company was reported, at the end of 1913, to be pumping sulphur at the rate of about 100 tons per week. The developments at this place—the Bryan Heights dome—have not come up to expectations as the company's first well had to be repiped and operations were not steady during most of the year. A shipment of 730 tons was made to New York during December, 1913. The company is now building a new steaming unit which should be ready for operation during 1914. This is in addition to the first unit which had a capacity of 120,000 tons annually and consisted of four 750-h. p. Sterling water-tube boilers for heating the water used in extracting the sulphur. The construction work now under way will cost in the neighborhood of $150,000 and will result in increased sulphur production. The new unit is to have a battery of boilers rated at 8000-h. p. for the introduction of the superheated water which will make the second superheated water unit installed at the Freeport Sulphur

[1] *Eng. Min. Jour.*, Jan. 17, 1914.

field. The doubling of the capacity of the plant at the mines whereby an increased supply of superheated water may be forced into the sulphur formation to melt out the mineral so that it may be pumped to the surface will actually mean more than doubling the output as has been found by experience. Steady shipments of sulphur have been going by rail to the eastern and northern markets for the past few months.

The total production of sulphur in the state of Texas for the year 1913 was about 12,000 tons, valued at $240,000.

There is an area of sulphur-bearing gypsum and limestone in Culberson County, trans-Pecos Texas, which would appear to merit attention. It has been described by Wm B. Phillips.[1]

Foreign Sulphur Industry

Chile.—The Solfataras of Tacna are very important and there is a plan to connect the deposits with the railroad under construction from Arica to La Paz. When worked on a large scale these deposits will be able to compete with foreign sulphur, not only in Chile itself but in the Argentine, Peru, Ecuador and Bolivia as well. The sulphur industry of Tacna has a great future before it.

England.[2]—In view of the increasing prices demanded by Italian producers of refined sulphur it is believed that the future will see an increasing demand for the American product. The ruling price in London of refined sulphur is $25.55 per ton (2240 lb.), being an increase of about $2.43 over the price a year ago. Hitherto Italy has been the chief source of supply. The imports from that country during the calendar year 1912 amounted to 21,615 tons, worth $542,225, while the importations from all other sources were only 145 tons valued at $4842.

Italy.[3]—The decline in production, as has been the case for the years 1911 and 1912, still continues, although the decrease for 1913 was only about one-half that for 1912. The output of Sicilian sulphur is not expected to increase during the next few years for several reasons. The existing mines have mostly reached deep levels and owing to this the cost of production is increasing. The latter is also due, in a measure, to a rise in wages in consequence of the great emigration of laborers from Sicily. For these reasons the mines must be worked more and more by machinery, thus requiring a considerable investment which is not always easily available.

According to the official report of the Consorzio for the seventh working year from August 1, 1912 to July 31, 1913, the total production of sul-

[1] Wm. B. Phillips, *American Fertilizer*, Vol. XXXVI, No. 12; *Bulletin* No. 2, University of Texas Mineral Survey.
[2] Depy. Consul Gen. Carl R. Loop, *Daily Consular and Trade Reports*, 1913.
[3] Consul Hernando De Soto, Palermo, Italy, *Daily Consular and Trade Reports*, 1913.

phur in Sicily was 351,752 tons, against 366,457 tons in 1911–1912 and 391,908 tons in 1910–1911. These figures show a gradual decrease during the past two working years, the production declining by 25,451 tons in 1911–12, as compared with that of 1910–11 and by 15,489 tons in 1912–13, as against that of 1911–12.

The total sales during 1912–13, including sales for future delivery, amounted to 497,246 tons, against 603,255 tons in 1911–12 and 816,818 tons in 1910–11. On July 31, 1913, there remained to be delivered on sales made 589,477 tons, of which 249,783 tons were booked for delivery during 1913–14 and 339,694 tons during the following years.

The total exports declined from 447,638 tons in 1911–12 to 434,473 tons in 1912–1913.

The following table shows the stocks and exports from Sicily in recent years. The production is stated as follows: The production in 1906 was 471,190 tons; 1907, 399,672 tons; 1908, 404,297 tons; 1909, 402,353 tons; 1910, 397,808 tons; 1911, 376,171 tons; 1912, 357,547; 1913, 349,602 tons.

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1905–1913.
(In metric tons.)

Country.	1905.(a)	1906.(d)	1907.(d)	1908.(d)	1909.(d)	1910.(d)	1911.(d)	1912.(d)	1913.(d)
Austria	25,111	24,703	26,390	22,086	26,560	29,601	34,136	38,362	34,543
Belgium	14,442	8,538	8,066	8,746	16,377	14,305	11,771	10,723	12,399
France	96,170	71,021	59,868	96,448	90,239	93,229	114,868	104,109	79,927
Germany	28,319	40,113	35,059	30,229	28,538	30,225	28,664	32,286	35,091
Greece and Turkey	25,069	25,136	27,969	24,838	16,309	21,435	24,933	15,436	19,792
Holland	4,425	10,037	14,951	9,812	8,708	9,731	10,549	14,019	12,518
Italy	99,633	81,329	57,743	60,134	49,692	61,269	72,959	84,952	82,348
Portugal	13,196	15,968	13,328	17,586	21,036	18,758	25,121	21,314	15,794
Spain	2,478								
Scandinavia (c)	18,288	21,605	23,415	30,366	19,905	20,354	29,741	35,111	38,092
Russia	16,673	18,174	21,244	14,068	18,584	25,866	23,485	25,563	27,358
United Kingdom	18,847	18,687	17,929	20,597	19,860	19,074	19,936	19,830	17,540
United States	70,332	37,725	4,047	9,654	14,706	12,205	8,482	2,856	1,792
Other countries(b)	23,277	28,591	31,942	30,509	33,999	36,935	49,181	42,731	50,903
Totals	456,260	401,627	341,951	375,037	364,513	393,987	453,826	447,292	428,097
Stock in Sicily, Dec. 31	462,437	523,586	594,459	616,419	647,880	640,711	551,442	450,917	376,365

(a) Reported by Emil Fog & Sons, Messina. (b) Mainly South Africa, Northern Africa, Asia, Australia, and the East Indies. (c) Including Norway, Sweden and Denmark. (d) Reported by Parsons & Petit, New York. (e) Includes Canada.

The most striking decline in exports is that to France which was always considered the best customer and which took over 30,000 tons less than in the preceding year. The decline is believed by the Consorzio to be due to the establishment by the Union Sulphur Co. of large refineries at Marseilles. On the other hand exports to Germany increased by about 6000 tons, to Norway by 5000 tons, to Russia by 4500 tons, to Turkey by 4300 tons, to Sweden by 3400 tons, which in part counterbalanced the smaller purchases by France.

Since the production was much lower than in preceding years, even

though the exports were somewhat lower, the decrease in stocks continued in 1913.

The failure to reach in 1913 a normal production of 400,000 tons, as was anticipated is attributed to scarcity of labor and high wages and to the closing in 1913 of seven mines in addition to the sixteen mines closed in 1912.

The Consorzio believes that the steady increase in the consumption of sulphur and the limited production in Sicily will permit the coexistence of the two most important sulphur producers in the world's market without prejudice to the progress of the Sicilian sulphur interests.

Japan.—Japan continued to ship sulphur to the Pacific coast and anticipates some extension of trade with the opening of the Panama Canal. Coast prices remain the same as last year.

Mexico.—Some 25 miles south of Guadalcazar, San Luis Potosi, is a sulphur mine, the largest producer in Mexico, which has a capacity of 25 tons of refined suphur a month. This mine has been worked for more than 50 years and was purchased by Americans about 15 years ago and later leased by them to German interests, and the bulk of the product has been shipped to Germany. The sulphur is encountered in the form of brimstone from 37 to 90 per cent. sulphur very near the surface. The mining company owns and operates a short line of railroad connecting with Cerritos.

The volcanic sulphur deposit at Cerritos owned by the Virginia Carolina Chemical Co. was not operated in 1913 on account of disturbed conditions in Mexico.

It is understood that a company was again floated to operate the sulphur deposit of the well-known Mexican volcano, Popocatepetl. This deposit is too far inland for commercial production except for local trade.

Philippine Islands.—In the Philippines, as in Japan, sulphur is found in connection with extinct or dying volcanoes. In many places are encountered small cones of nearly pure sulphur built up around vents from which have issued, and in some cases still issue, sulphurous gases. Sulphur is also found permeating the volcanic rocks in the neighborhood of these vents. It is quite possible that boring in and about volcanic regions in the Philippines will disclose important quantities of sulphur-permeated rock. When the sulphur content is not less than 8 or 10 per cent., such material can be worked profitably where labor and transportation conditions are favorable. There are no estimates of the quantity of sulphur available, except in the case of the Biliran island and Leyte deposits. Goodman, formerly of the Philippine Bureau of Science, estimated that there were possibly 3000 tons in the three deposits in sight. Of the amount on the island of Camiguin (north of Luzon), Ferguson,

formerly of the Bureau of Science, could give no estimate, but reported that there was apparently a commercial deposit.

New Zealand.—An interesting and apparently valuable deposit of sulphur is being worked on White Island. About 6500 tons of rock sulphur and flowers of sulphur were found in such shape as to be readily extracted. A more important source of sulphur is a boiling spring which pours out a continuous stream of liquid product estimated at several tons per hour and running as high as 94 per cent. sulphur. There was on the dumps at last reports about 4000 tons of material running from 60 to 70 per cent. sulphur and 700 to 800 tons of pure sulphur which needs practically no refining.

WORLD'S PRODUCTION OF SULPHUR. (a)
(In metric tons.)

Year.	Austria. (b) (e)	Chile.	France. (b)	Germany.	Greece.	Italy. (b)	Japan.	Spain.	United States.	Total.
1897.....	642	664	10,723	2,317	358	496,658	12,013	(b)3,500	1,717	528,592
1898.....	589	1,256	9,818	1,954	135	502,351	10,339	3,100	2,770	532,312
1899.....	671	989	11,744	1,663	1,150	563,697	10,241	1,100	1,590	592,290
1900.....	985	2,472	11,551	1,445	891	544,119	14,439	750	4,630	581,282
1901.....	5,048	2,516	6,836	963	2,336	563,096	16,548	610	6,977	604,930
1902.....	3,826	2,636	8,021	487	1,391	510,333	18,287	450	7,565	552,996
1903.....	4,610	3,560	7,375	219	1,266	553,751	22,914	1,680	35,660	631,035
1904.....	6,431	3,594	5,447	209	1,225	527,563	25,587	605	196,588	767,249
1905.....	8,542	3,470	4,637	205	1,126	568,927	24,652	610	218,440	830,609
1906.....	15,258	4,598	2,713	178	(d)1,000	499,814	27,589	700	298,704	845,956
1907.....	24,199	2,905	2,000	176	(d)1,000	426,972	33,329	3,612	312,731	801,911
1908.....	17,429	2,705	2,189	811	(d)1,000	445,312	33,419	13,872	312,700	829,437
1909.....	12,856	4,508	2,900	1,185	(d)1,000	435,060	36,317	21,750	303,000	817,608
1910.....	15,976	3,823	2,641	1,272	.....	430,360	43,848	30,113	259,699	.....
1911.....	15,856	4,451	1,200	1,251	174	414,671	52,064	40,662	246,300	.....
1912.....	14,979	4,431	1,108	(c)	2,016	357,547	55,005	42,344	800,300	.....
1913.....	10,561	.....	.....	.....	.....	349,602	.....	.....	.....	.....

(a) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (b) Crude mineral; limestone impregnated with sulphur. (c) Not yet reported. (d) Estimated. (e) Includes such production from Hungary.

Occurrence of Native Sulphur

Native sulphur occurs in various parts of the world in volcanic regions in which active or extinct volcanoes exist and in beds of gypsum and associated rocks. On the island of Sicily it occurs in the valley of Noto and Mazzaro. It is found at a number of places on the mainland of Italy. It occurs in Romagna and Marche in central Italy, in the Apennines, between Porli and Macerata; and in southern Italy in the province of Avellino, in the Sabbato valley and in Calabria, in the region of Catona. Small quantities have been found in Solfatara near Naples. It is found as a deposit from hot springs in Iceland, Switzerland, Savoy, Hanover, and elsewhere. Large deposits are found in Louisiana and have been reported from Russia in Kyrk-Tschulva in the Trans-caspian district of Aschabad, near Schjich. It is also found in Egypt, South America, Mexico, Canada, India, Philippine islands, and in a number of our western states.

Pyrite

The production of pyrite in the United States during 1913 fell off somewhat. The total amount produced was 341,338 long tons, valued at $1,286,084 as against 350,928 long tons, valued at $1,334,259 for 1912, a decrease in quantity of 9590 long tons, and a decrease in value of $48,175.

The production in the leading states—Virginia and New York—diminished slightly, while in both California and Wisconsin there was an increased production. The output of by-product pyrite, obtained in connection with coal mining fell off considerably.

The consumption of pyrite in the United States also declined during 1913 owing to the fact that about seventy of the fertilizer works in the south closed their acid-making departments for several months. In general, the domestic pyrite mines operated at about normal capacity where their output was contracted for in advance, but the sulphuric acid of the Tennessee smelters was offered at a sufficiently low price to induce a number of fertilizer works to shut down their pyrite burners as they found it cheaper to buy acid than to make it.

For the above reason and also partly due to the oversupply in 1912 the importations of pyrite from Spain and Portugal declined sharply in 1913.

The total imports of pyrite for consumption[1] during the calendar year 1913 were 850,592 long tons, valued at $3,611,137. These figures show a notable decrease in quantity, 120,193 long tons, and in value, $230,546, as compared with the imports of 1912 which amounted to 970,785 long tons, valued at $3,841,683.

As has been the case heretofore only about one-fourth of the total consumption of pyrite in the United States is supplied by domestic producers. The total consumption of pyrite is shown in the table.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITES IN THE UNITED STATES. (a)
(In tons of 2240 lb.)

Year.	Production.		Imports. (b)		Consumption.	
1899	178,408	$583,323	310,008	$1,074,855	488,416	$1,658,178
1900	201,317	684,478	322,484	1,055,121	523,801	1,739,599
1901	234,825	1,024,449	403,706	1,415,149	638,531	2,439,598
1902	228,198	971,796	440,363	1,650,852	668,561	1,622,648
1903	199,387	787,579	425,989	1,628,600	625,376	2,416,179
1904	173,221	669,124	413,585	1,533,564	586,806	2,202,688
1905	224,980	752,936	515,722	1,780,800	740,702	2,533,736
1906	225,045	767,866	597,347	2,138,746	822,392	2,906,612
1907	261,871	851,346	656,477	2,637,485	918,348	3,488,831
1908	206,471	744,463	668,115	2,624,339	874,586	3,368,802
1909	210,000	756,814	692,385	2,428,638	902,385	3,185,452
1910	223,700	830,150	806,590	2,773,627	1,030,290	3,603,777
1911	299,904	1,150,597	1,001,944	3,788,632	1,301,848	4,939,229
1912	350,928	1,334,259	964,478	3,860,738	1,315,406	5,194,997
1913	341,338	1,286,284	850,592	3,611,137	1,192,930	4,897,421

(a) These statistics do not include the auriferous pyrite used for the manufacture of sulphuric acid in Colorado. (b) Net imports, less re-exports of 3060 tons in 1902 and 1330 tons in 1903.

[1] U. S. Geological Survey.

By-product sulphur is not included in the above pyrite production, and the sources of this sulphur are given under sulphuric acid.

The greater part of the imported pyrite comes from Spain, a small quantity from Portugal and the rest from Canada. Nearly all of this pyrite is originally classed as copper ore, some of it coming into the country as such, while the rest of it is known as leached ore. As a rule the imported pyrite contains less than 0.7 per cent. of copper though considerable comes in carrying up to 1.25 per cent. This latter ore has been leached by piling up the ore and allowing it to weather thus oxidizing the sulphide of copper to sulphate which can be readily washed out. In this way about three-quarters of the total copper is removed, still leaving the ore in condition for use in the pyrite burners. In a few plants this residue of copper is recovered from the cinder by systematic leaching of the cinder with dilute sulphuric acid. A higher grade of ore is also brought in containing up to 2.25 per cent. of copper. This ore after passing through the burners is given a chloridizing roast and then leached with dilute acid to recover the copper.

Since but little pyrite is mined in this country in proportion to the total consumption, the market is almost entirely controlled by the importations. While the prices are to a considerable extent dependent upon the importations, the latter and consequently the prices themselves are affected by local condition. The importations have been below normal for the last two years, figuring the normal at 1,000,000 tons, it being claimed that the demand in 1912 was affected by the overextension of the phosphate industry in 1911. The two principal causes of low importations in 1913 were an oversupply and the decreased use of pyrite by the fertilizer interests due to the low price of smelter acid.

The prices in this country are about the same as in 1912. Furnace size ore ranged from 13 1/4 to 13 1/2 cents per unit and fines 12 cents. Domestic prices varied from 8 to 10 cents per unit and averaged about 9 cents f.o.b. mines.

Pyrite Mining in the United States

Since the continued high price of sulphur militates against its use for the manufacture of sulphuric acid, the acid industry depends upon the supply of pyrite and since the domestic supply of this article is comparatively small, this should be an incentive to the prospecting for new deposits. Considerable work has been done in this direction in Canada but at the present time it is too early to predict results. Most of the ore worked there at the present is for its copper content rather than for its sulphur.

The Arminius, Sulphur Mines and St. Lawrence properties were all operated in 1913 and, as was to be expected, about one-half of the total domestic output was produced by these three companies. The most important domestic transaction was the purchase of the Boyd Smith mine in Virginia by the Boyd Smith Mines, Inc. in which Harrison Bros. Co., of Philadelphia are interested. According to the present plans the shaft will be sunk to the 400-ft. level and the mill will be enlarged.

Besides the St. Lawrence Co's. output in New York State, a small production was made by Homer L. Drake of Gouverneur, a property at Fowler, north of Silver Lake in St. Lawrence County, New York, the output being used by local pulp manufacturers. The Northern Pyrites Co. property in Western Ontario was operated in 1913 by the General Chemical Co. of New York.

Alabama.—The only mines of any account are those near Pyriton, Clay County and these have not been worked for the past 2 or 3 years.

California (By F. McN. Hamilton).—Pyrite production in California during 1913 amounted to 79,000 tons, the value of the crude ore at the property being $218,537, or at the rate of $2.77 per ton. This is an increase, as shown by the following table, over the total production and value for the preceding year, but is a decrease in the price per ton which was $2.91 in 1912.

These figures refer to pyrite actually sold and used in the manufacture of sulphuric acid and take no account of the thousands of tons of pyrite ore which are annually treated for other than their sulphur content. The output here given comes from Alameda and Shasta Counties, as has been the case since the inception of the mineral industry in California in 1898.

California's output of pyrite, by counties, for the last 2 years is as follows:

County.	1912.		1913.	
	Short tons.	Value.	Short tons.	Value.
Alameda	7,267	$29,068	6,029	$24,128
Shasta	62,605	174,402	72,971	194,409
Total	69,872	$203,470	79,000	218,357

Georgia.—As in recent years only two producers mined pyrite in the state these being the mines at Villa Rica, 30 miles west of Atlanta and the mine of the Sulphur Mining and R. R. Co. The output for 1912 was, in round numbers, about 6000 tons while that for 1913 was in the neighborhood of twice that or about 12,000 tons.

Illinois.—Pyrite is obtained from coal by hand picking at a few mines in Illinois and is sold for the manufacture of sulphuric acid. In 1912 the amount so produced was 27,000 tons valued at $62,980.

Indiana.—A small amount of pyrite is produced from the coal washeries of this state but the output is very small, probably being less than 500 tons.

Massachusetts.—Although formerly there was considerable pyrite of exceptional purity produced in this state the production at the present time is practically nothing as the only mine of any importance has suspended operations.

Virginia.—This state produces about half of the pyrite mined in the United States, the ore running in the neighborhood of 48 per cent. sulphur. The principal producing properties are located in Louisa and Prince William Counties and are known as the Arminius, the Sulphur Mining and R. R. Co., and the Cabin Branch properties.

The total amount of pyrite produced in Virginia, inclusive of pyrrhotite for the past several years is as follows:

Year.	Long Tons.	Value.	Average Price per Ton.
1908	116,340	$435,522	$3.74
1909	114,176	423,283	3.71
1910	140,106	525,437	3.75
1911	150,800	558,494	3.70
1912	162,487	621,219	3.82
1913	148,259	587,041	3.96

Michigan (By R. C. Allen).—Iron pyrite occurs in seams and nodules in some of the coal beds of the state and is also associated with iron ores in the northern peninsula. Several years ago there was an attempt made to develop the pyrite associated with the coal at Sebewaing, Huron County, but the venture was not successful. No important deposits have been recently discovered.

New York.[1]—Pyrite is found through a large belt extending from near Antwerp, across Gouverneur, De Kalb and Hermon townships, a district of over 40 miles being the same belt which carries red hematite ores.

The two companies now operating are the St. Lawrence Pyrites Co., with mines and concentrating plant between Hermon and De Kalb Junction; and the Cole mine 4 miles southeast of Gouverneur and now operated by the Hinckley Fiber Co. of Hinckley, N. Y. Mines at High Falls or pyrites have been taken over by the United States Steel Co. and are not being worked. The total production of pyrite in this state for 1913 was 54,903 tons valued at $243,066.

The St. Lawrence Pyrite Co. has been producing for a number of years

[1] P. B. McDonald, *Eng. Min. Jour.*, April 5, 1913.

and is ranked as one of the four principal producers of pyrite in the United States. Its mines, better known as the Stella mines, include two shafts on parallel deposits 1600 ft. apart. The northwest shaft, known as the Stella, is not operated at present; at this mine the ore-body averages 10 ft. thick, extends 1100 ft. along the strike and has been worked 900 ft. down the dip. Considerable pyrrhotite occurs in the ore. The Anna shaft, where present mining is in progress, is on a parallel lens of ore averaging 20 ft. thick.

The ore carries 15 to 40 per cent. of sulphur with an average of about 21 per cent. Practically all the mine output is concentrated and though rather low-grade ore it is free from arsenic and injurious impurities. The ore is put through jaw crushers at the shaft house and is then taken to the mill and passed through gyratory crushers, trommels, and three sets of rolls and concentrated in two 25-ft. Hancock jigs. The tailings from the Hancock jigs are treated in Harz jigs and the fines are concentrated on 10 Wilfley tables and one Deister table. During the winter the concentrates are dried to prevent freezing, in a Ruggles-Coles dryer.

The mill is designed for 500 tons capacity per 24 hours and reduces the mine output about one-half in weight, sending out concentrates running about 44 per cent. of sulphur. The product is sold to paper mills in the East as a rule, although a small amount is shipped up the Lakes.

The Cole Mine near Gouverneur is a small mine, being partially an open cut, only a depth of 60 ft. having been reached. The ore shipped is crude and averages about 30 per cent. of sulphur. This mine is operated by the Hinckley Fiber Co. which uses the product in its paper mill at Hinckley, N. Y., for making sulphurous acid to be used in the sulphite paper process.

Pennsylvania (By H. C. Demming).—There was no production of pyrite in Pennsylvania in 1913. Prior to that year there had been a small production of pyrite from one producer in Crawford County, Pennsylvania, the same being a by-product at one of the coal mines, probably from the Brookville coal.

Wisconsin.—The production of pyrite in this state is considerable, it being mined for its sulphur content and also for its content of zinc. The output of the state since 1907 is shown in the following table:

ANNUAL PYRITE PRODUCTION.

	Short Tons.	Value.	Average Price per Ton.
1908	2,536	$8,740	$3.45
1909	7,970	27,337	3.43
1910	14,081	49,467	3.52
1911	12,893	50,025	3.88
1912	17,898	70,518	3.94
1913	25,328	94,727	3.74

The Wisconsin ore together with that produced in connection with the mining of coal in Illinois, Indiana and Ohio and the Canadian ore brought into this country by way of Chicago supplies most of the demand of the acid manufacturers in the middle west.

WORLD'S PRODUCTION OF PYRITE.
(In metric tons.)

Year.	Belgium.	Bosnia.	Canada.	England.	France.	Germany.	Hungary.	Italy. (a)
1899	283	.....	25,112	12,426	318,832	144,623	79,519	76,538
1900	400	1,700	36,308	12,484	305,073	169,447	87,000	71,616
1901	560	4,570	31,982	10,405	307,447	157,433	93,907	89,376
1902	710	5,170	32,304	9,315	318,235	165,225	106,490	93,177
1903	720	6,589	30,822	9,794	322,118	170,867	96,619	101,455
1904	1,075	10,421	29,980	10,452	271,544	174,782	97,148	112,004
1905	976	19,045	29,713	12,381	267,114	185,368	106,848	117,667
1906	908	13,474	35,927	11,318	265,261	196,971	112,623	122,364
1907	397	3,671	35,494	10,357	283,000	196,320	99,503	126,925
1908	357	5,000	42,934	9,599	284,717	219,455	95,824	131,721
1909	214	(b)	58,645	8,564	273,221	198,688	98,971	149,084
1910	213	571	48,871	10,393	250,432	215,708	92,464	165,688
1911	122	3,118	74,978	10,276	277,900	217,459	96,754	165,273
1912	148	6,216	73,944	10,691	282,202	242,121	103,809	277,585
1913	268	.....	207,532	11,611	.....	.....	.....	.....

Year.	Japan.	Newfoundland.	Norway. (c)	Portugal. (c)	Russia.	Spain.	Sweden.	United States.	Total.
1899	8,376	26,154	95,636	347,234	23,250	107,386	150	181,263	1,446,782
1900	16,166	*Nil*	98,945	402,870	23,154	34,638	179	204,538	1,464,512
1901	17,589	7,532	101,894	443,397	30,732	33,953	*Nil*	238,582	1,568,999
1902	18,580	26,000	121,247	413,714	26,465	145,173	*Nil*	231,849	1,713,654
1903	16,149	42,674	129,939	376,177	22,780	155,739	7,793	202,577	1,692,812
1904	24,886	61,166	133,603	383,581	31,667	161,841	15,957	175,992	1,696,099
1905	25,569	51,534	162,012	352,479	30,689	179,079	20,762	228,580	1,789,816
1906	36,038	28,583	197,886	350,746	20,660	189,243	21,827	228,646	1,832,475
1907	56,166	28,000	236,038	241,771	18,316	225,830	27,000	266,061	1,854,849
1908	33,867	(e)35,000	269,129	81,417	56,345	263,457	29,569	209,774	1,768,365
1909	27,066	*Nil*	282,606	284,735	(b)	236,000	16,104	213,371	(e)1,730,000
1910	78,418	*Nil*	322,000	312,906	(e)50,000	294,184	25,445	227,280	1,826,854
1911	73,879	2,500	(e)350,000	282,773	.....	344,879	30,096	304,902	.....
1912	74,929	*Nil*	469,326	(f)601,443	.....	500,000	31,835	356,777	.....
1913	.....	.....	470,000	.....	.....	.....	.....	347,027	.....

(a) Cupriferous in part. (b) Reports not yet available. (c) Both iron and copper pyrites. (d) Not including Newfoundland. (e) Estimated. (f) Includes 120,148 tons copper iron pyrite.

Foreign Pyrite Industry

Canada.[1]—The production of pyrite in Canada is on the increase and considerable prospecting work is being undertaken. The increasing use of pyrite in the manufacture of paper pulp is the principal reason for this, coupled with the fact that the consumption is much greater than the supply. Even so, the greater portion of the production is sent into the United States, principally through the ports of Buffalo and Chicago, in consequence of which the Canadian demand is partially supplied by Spanish pyrite.

[1] A. W. G. Wilson, *Can. Min. Jour.*, April 15, 1913.

In Eastern Ontario there are at present being worked 5 properties producing ore which runs as high as 46 to 48 per cent. sulphur, but the most of the output is around 36 per cent.

In Northern and Western Ontario there are 5 properties producing about the same grade of ore as the eastern companies. Besides pyrite there is considerable pyrrhotite found in Ontario, the most important known deposits of which are the nickel-copper bearing pyrrhotites of the Sudbury district. Exploration work shows that there are probably nearly 50,000,000 tons of this ore available, much of which contains over 25 per cent. of sulphur. This ore is not of importance as far as its content of sulphur is concerned at the present time, but may become so in the future unless extensive deposits of pyrite are uncovered.

Pyrite has been reported from several places in British Columbia, but for the most part these are valuable more for their copper and gold content than their sulphur content. At the present time no pyrite is mined in British Columbia for its sulphur content and none is imported, but it is possible that in the future with the development of industries requiring sulphur, there may be a market for sulphur-carrying ores. Present needs are satisfied by the importation of Japanese sulphur which costs $17 to $18 per ton in cargo lots at seaboard points.

The two most important pyrite deposits are those of the Granby Consolidated Mining and Smelting Co., and the British Columbia Pyrites Co. Samples from the latter property show 40 to 48 per cent. sulphur.

In the Province of Quebec there are two operating pyrite mines with large ore reserves, which are favorably located with reference to the industries of the St. Lawrence valley. These ores are considerably higher in sulphur than those of Ontario.

The Ontario Bureau of Mines states that during the year 1910 the average price at the mine for Ontario pyrites was $2.90 per ton.

There are no accounts of the pyrite imported into Canada in recent years and the consumption of pyrite in Canada is not easily determined.

Belgium.—Belgium produces somewhere in the neighborhood of 50,000 tons of leached cinder annually from cupriferous pyrite. This cinder is in demand for use in blast-furnaces.

Japan.—The production of pyrite in Japan during 1912 amounted to 83,426 short tons valued at $218,296.

Norway[1].—An amount of pyrite is produced in this country which is close to half a million tons per year. The most of it is cupriferous ore and is utilized both for its content of copper and sulphur. In 1912 Norway exported 390,733,200 kilos valued at 9,377,600 kronen.

Late in 1913 a concession was granted to a Norwegian company to

[1] Consul General Michael J. Hendrick, Christiana, *Daily Cons. and Trade Rept.*, 1913.

operate pyrite deposits known to exist in the vicinity of Ballanghalvoen, in Ofoten. These deposits contain 33 per cent. of sulphur and only 1 per cent. of copper. Large crushing and washing plants will be erected at the mines, the yearly production being figured as 100,000 tons of salable product together with several thousand tons of copper ore. It is estimated that the enterprise will require an outlay of about $1,200,000, in addition to which about $161,000 will be used in developing hydroelectric power to operate the machinery. Although the ore is very low grade, it is expected that by the use of modern methods and with the immense deposits known to exist, that the enterprise will be very successful. The concession is limited to 55 years, after which the plant is to revert to the Norwegian state.

Roumania.—A pyrite deposit has lately been opened up at Altan-Tepe in the Dobrutsha. About 50,000 tons of ore have been developed and remunerative mining will probably be possible as soon as the Tulcea-Medjidia Railroad line is finished. The line now in course of construction passes the deposits at a distance of about 5 miles.

Spain.—The pyrite sulphur ores are in part classified as copper ores in the reports of the government, so that it is impossible to make an estimate from these reports.

The official figures of the exportations of pyrites and of minerals containing less than 2.5 per cent. of copper are as follows for the last three years:

1911	about 2,800,000 tons
1912	about 3,040,000 tons
1913	about 2,975,000 tons

It can be deduced from these figures that the diminution in the exportation during 1913 is due to the strikes that have taken place in the different centers of production and in particular at Rio Tinto.

For some time past certain exporters have been demanding payment for the iron content of the pyrite.

Technology

Pyrite Cinder.[1]—At the present time there is an increasing tendency to utilize the heretofore waste cinder of the pyrite burners as a source of iron, and several plants have been undertaken to prepare the cinder for the blast-furnace. The most comprehensive of these is the plant under construction at Roanoke, Va., by the Pyrites Co. Ltd., which is associated with the interests controlling the Rio Tinto Mines in Spain which ship

[1] *Journ. Ind. Eng. Chem.*, Apr., 1913.

pyrites to this country. After the ore is used by the acid manufacturers, the residue is to be collected at the Norfolk plant where the copper will be removed and the material sintered for the reclamation of the iron. The sintering is to be carried out in a unit of the Dwight and Lloyd type of 150 ton size. As the pyrite ore contains 60 per cent. or over of iron and the sintered product will run about 0.02 per cent. of phosphorus it is thought that this material will be attractive to blast-furnaces in Virginia and Southern districts

Sulphur from Smelter Gases.[1]—The Hall desulphurizing process consists in roasting ore—pyrite, pyrrhotite, copper matte, zinc concentrates, etc.—in a reducing or neutral atmosphere containing some hydrocarbon gas and steam. All the sulphur distils in elemental form, the metal being left as oxide. The sulphur fumes are then readily collected in water.

Tests have been made abroad and many analyses show less than 1 per cent. of sulphur remaining in the cinder. The distillation is obtained by the direct application to the ore of a burning gas flame of slightly reducing, or at least, non-oxidizing character, accompanied by sufficient water in the form of water of formation or by the addition of small amounts of extraneous water in the shape of steam. This water is decomposed by the hot ore; nascent oxygen goes to the metal and nascent hydrogen combines with any free oxygen that may enter the furnace through the atomizer through which the gases are admitted thus creating a sort of cycle of water decomposition and water formation from the combustion of the hydrogen so derived.

When the burners on the furnace are properly adjusted the final discharge of hydrogen appears to be all in the shape of water vapor, *i.e.*, complete balances are easily maintained, whereby there is substantially neither sulphur dioxide nor hydrogen sulphide in the discharge, the tests being made on samples taken within a distance of 6 in. from the furnace. Analyses of the cinder show it to be a mixture of Fe_2O_3 and Fe_3O_4.

The temperature maintained in the furnace must be slightly above 700° C as that is about the distilling point of the sulphur, but below 900° C, the fusing point, thus allowing a range in temperature of 200° C.

The calculation of the cost of producing sulphur by this method in American smelting works is placed at $3 to $5 per ton of crude sulphur derived.

The fumes coming from the smelter are of a heavy yellow appearance with no appreciable odor other than that of the hot elemental sulphur vapor. The sulphur is extracted from the fume by simply washing or by running the fumes through the Cottrell electrical dust collector. The precipitated solids show by analysis 98 to 99.5 per cent. of sulphur, the

[1] Wm. A. Hall, *Eng. Min. Jour.*, July 5, 1913.

impurities being flue dust or lead or zinc sulphides. The refined sulphur has been found to be over 99.5 per cent. soluble in carbon bisulphide.

So far the process has been developed principally with the view of its attachment to multiple hearth roasters.

Thiogen Process.[1]—This process for the removal of sulphur dioxide from smelter fume is based upon the reduction of the sulphur dioxide to elemental sulphur by means of fuel oil. The roaster gases first pass through a dust settler which leaves it fairly clean, small amounts of dust seeming to produce no deleterious effect for some time. From the dust chamber the gas passes to the fore chamber where a certain amount of oil is introduced. Then the gases go to the contact chamber where additional oil is introduced. The relative amounts introduced at the two places are adjusted by temperature conditions which establish themselves in the contact chamber, the total amount being that necessary to burn out oxygen and reduce the sulphur dioxide. The contact material is made up from plaster of Paris which is mixed with water containing a small amount of iron salts, allowed to set and then broken into lumps. The issuing gases containing free sulphur pass to cooling and condensing apparatus where the sulphur deposits. The principal chemical difficulties have had to do with the poisoning of the contact material owing to deposition of the flue dust thereon, high temperatures and the presence of foreign substances.

Paper Pulp.[2]—Up to within very recently paper pulp has been made almost exclusively from sulphur which, in the case of Canadian pulp, was formerly imported from Sicily, but of late years has been largely obtained from Louisiana. However, in foreign countries, particularly Germany and Sweden, pyrites have for some time been used. Although sulphur has the advantage that it produces more easily a strong and uniform acid still several companies in the United States are now burning pyrites successfully and with marked economy over sulphur.

Sulphur in Coal.—An attempt has been made to utilize the sulphur containing the coal used in the manufacture of coal gas for neutralizing the ammonia. At present there are two schemes under way with this idea in view.

In the Burkheiser process the sulphur, absorbed by oxide, is converted into sulphurous acid by a powerful air blast which is afterward scrubbed with water. The gas, containing the ammonia, is then treated in a washer with this acid liquor when ammonium sulphite is formed. This salt which sublimes below 100° C is oxidized by a second air blast to the sulphate.

[1] *Jour. Ind. Eng. Chem.*, April, 1913.
[2] *Jour. Soc. of Chem. Ind.*, May 15, 1913.

The Feld system is somewhat more complicated and is dependent upon the introduction of an outside product—sulphate of iron—for bringing about the necessary change; while the surplus sulphur is received in the pure form.

BIBLIOGRAPHY

ANON.—Les Pyrite. *Le Phosphate*, Sept., 1913.

ANON.—Les Pyrites et les Mines Pyritiques. *Le Phosphate*, Feb. 24, 1913.

ANON.—Sulphur and Sulphuric Acid in the United States. *Chem. Trade Jour.*, **53**, 101.

BALL, H., AND SHALER, M. K.—Mining in the Belgian Congo. *Min. Sci. Pr.*, Feb. 21, 1914.

BANCROFT, J. AUSTIN.—Geology of the Coast and Islands between the Strait of Georgia and Queen Charlotte Sound, British Columbia. *Memoir*, No. 23, Canada Dept. of Mines, Geol. Survey.

BLANQUIER, JOHN.—Sulphur Industry of Sicily. *Min. Jour.*, June 28, 1913.

CREMER, OBERBERGRAT.—Berichte über eine Reisein der chinesischen Provinz Szetschuan. *Zeit. Berg. Hutten u. Salin*, 1913, Vol. LXI, Part 1.

DAVIS, A. W.—Melting Process Applied to Sulphur Mining in Texas. *Min. Sci.*, Aug., 1913.

DAVIS, A. W.—Texas Sulphur Deposits. *Amer. Fertilizer*, May 17, 1913.

ELSMAN, J. G. F.—Sulphur in the West Indies. *Pharm. Weekblad.*, **49**, 214.

FRASCH, HERMAN.—Desulphurizing Petroleum and the Production of Sulphur in Louisiana. *Met. Chem. Eng.*, Feb., 1913.

FRENTZEL, A.—Die Erdol, Bitumen und Schefellager von Teljusvhi. *Petroleum*, June 4, 1913.

GRILLO, G.—Company Report on Sulphur in Sicily. *Rassegna Mineraria*, May 1, 1913.

HESS, F. L., HEWETT, D. F., LARSEN, E. S., HUNTER, J. F.—Sulphur in Utah, Wyoming and Colorado. *Bull.* 530, U. S. Geol. Surv.

LANG, HERBERT.—Common Sense of the Fume Question. *Min. Sci. Pr.*, Aug. 2, 1913.

LIDDELL, D. M.—Hall Desulphurizing Process. *Eng. Min. Jour.*, July 12, 1913.

PHALEN, W. C.—Sulphur, Pyrite and Sulphuric Acid. *Am. Fertilizer*, Aug. 9, 1913.

SPRINGER, J. F.—Sulphur and Iron Deposits of Virginia. *Min. Eng. World*, March 15, 1913.

STUTZER, O. Original Sulphur Deposits. *Econ. Geol.*, 1913, 733.

UHLMANN, P. W.—Norwegischer und spanischer Kies als Rohmaterial für die Schwefelsaurefabrikation. *Chem. Ztg.*, Jan. 13, 1914.

WATSON, THOS. J.—The Mineral Production of Virginia in 1912. *Min. Eng. World*, Nov. 22, 1913.

WHITMAN, A. R.—The Vadose Synthesis of Pyrite. *Econ. Geol.*, Aug., 1913.

WOLFF, BERGRAT.—Die Erzlagerstatte des Rammelsberges. *Zeit. Berg. Hutten u. Salienw.*, Vol. LXI, Nov., 1913.

———. L'Industria Solfiferat Sciliana. *Rassegna Mineraria*, Feb. 1, 1914.

———————. Sizilliens Schwefelproduktion. *Kunstdünger-Industrie*, Sept. 15, 1913.

———————. The White Island Sulphur Deposit, New Zealand. *Eng. Min. Jour.*, Nov. 1, 1913.

Sulphuric Acid

The total production of sulphuric acid of all grades in the United States for the year 1913 was 3,538,980 short tons calculated to 50° B, valued at $22,366,482. Compared with the 1912 production of 3,462,000 short tons this shows an increase of 76,980 short tons. This output does not include a small quantity of fuming acid, but does include by-product acid, *i.e.*, acid obtained in the smelter industry. The acid produced at copper and zinc smelters in 1913 amounted to 790,296 short tons of 50° B acid valued at $4,346,172.

The most important commerical grades of acid are the 50° B or chamber acid containing 62.18 per cent. H_2SO_4 and having a specific gravity of 1.526; the 60° B or tower acid containing 77.67 per cent. H_2SO_4 and having a specific gravity of 1.706. This grade also includes concentrated chamber acid or lead acid. The 66° B or oil of vitriol contains 93.19 per cent. H_2SO_4 and has a gravity of 1.835. Besides these are the 97 per cent. acid, monohydrate and fuming acids which contain from 5 to 20 per cent. of dissolved trioxide.

About five-eighths of all the acid produced is chamber acid, the most of which is used in the manufacture of fertilizers from phosphate rock, the manufacture of sulphate of ammonia in connection with the destructive distillation of coal and the manufacture of alum. The most of the 60° acid is used in the steel industry for pickling purposes; the 66° acid is principally employed in the purification of petroleum and in the manufacture of mixed acid in the explosives industry as are also the higher strengths —the 97 per cent. and the fuming—the manufacture of reclaimed rubber and the general chemical industries.

The production of acid by grades is tabulated in detail below:

PRODUCTION OF SULPHURIC ACID IN THE UNITED STATES IN 1913, BY GRADES, IN SHORT TONS.

(Figures of the U. S. Geological Survey.)

Grade.	Quantity.	Value.	Price per Ton.
50° Baumé	1,643,318	$9,212,917	$5.61
60° Baumé	509,929	3,202,528	6.28
66° Baumé	797,104	9,282,422	11.65
Other grades	63,158	986,859	15.62
Total	3,013,509	22,684,526	7.53
Total reduced to 50° Baumé acid (a)	3,538,980	22,366,482	6.32

(a) Exclusive of a small amount of fuming acid.

PRODUCTION OF SULPHURIC ACID FROM COPPER AND ZINC SMELTERS IN 1911, 1912 AND 1913, IN SHORT TONS.
(Figures of the U. S. Geological Survey.)

Source.	60° Baumé Acid.								
	1911.			1912.			1913.		
	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.
Copper smelters..	207,657	$1,056,185	$5.09	(b)321,156	b) $1,985,704	(b)$6.18	336,019	$2,205,627	$6.56
Zinc smelters....	230,643	1,677,511	7.27	(b)292,917	(b) 2,255,237	(b) 7.70	296,218	2,140,645	7.23
Total.....	438,300	2,733,696	6.24	(b)614,073	(b) 4,240,941	(b) 6.91	632,237	4,345,272	6.87
Total acid reduced to 50° Baumé.	547,875	.....	.....	(c)764,237	.....	.....	790,296	.....	.....

(a) The acid reported to the Survey includes that of strength of 50°, 53°, 60°, and 66° Baumé, and a small quantity of electrolyte and oleum. All strengths, with the exception of the electrolyte, have been reduced to both 50° and 60°: Baumé, as given in the table.
(b) Inclusive of a small quantity of electrolyte.
(c) Exclusive of a small quantity of electrolyte.

The amount of by-product acid increased considerably over that obtained in 1912. This resulted in acid lower in price than could be made by the fertilizer manufacturers and curtailed the consumption of pyrite for the manufacture of fertilizer acid. During 1913 the amount of by-product acid obtained was 22.5 per cent. of the total as against 15 per cent. in 1912, an increase of approximately 50 per cent.

Markets.—The acid business saw a good year in 1913, being characterized by increased production and higher prices than in 1912, when there was a decreased output of fertilizer. Acid was quoted at $5.61 for 50° B acid per ton, $6.28 for 66° B acid and $11.65 for oil of vitriol.

Canada.—Canada manufactures practically all her acids, the amount imported being very small. While the demand has been moderate in the past, it is increasing very rapidly and there is every reason to suppose that the future will see an enormous expansion in this line of manufacture.

Sulphuric Acid Technology

The most recent advances in the manufacture of sulphuric acid during the year 1913 were the combined chamber and contact process, the Dwight and Lloyd process in acid burning, the Falding Acid Chamber and the Opl Acid Towers, all of which were noted in The Mineral Industry for 1912. One of the most promising phases of the industry is the increasing tendency to utilize the waste cinder from the pyrite burners for its content of iron and copper. The copper even when as low as 1 per cent. is advantageously leached from the cinder with weak sulphuric acid and subsequently precipitated from solution by scrap iron. The residual ma-

terial is being sintered for blast-furnace use to a greater extent than ever before and there is likely to be considerable expansion in this direction in the future.

During the past year different forms of mechanical burners and also fans for moving the gases came into more extended operation and there is a general tendency to appreciate the advantages of increased Glover Tower space. As a striking instance of reduced chamber space mention may be made of a works where two chamber sets were worked without towers. After denuding one set and increasing the height of the first and second chambers of the other—three chamber—set from 18 to 25 ft. introducing towers of liberal size, fan draft, and water spray instead of steam, 28 per cent. more acid has been produced with 67.7 per cent. of the orginal chamber space and 11.4 cu. ft. per pound of sulphur charged per 24 hours, the original chamber space being 24 to 25 cu. ft. per pound of sulphur charged per 24 hours.

A new method of introducing nitrous gases by spraying niter solution into the first chamber is reported to have given satisfactory results and appears likely to extend.

The Opl system has continued in constant use and is likely to be extended.

Mastic Lining.[1]—Asphaltic mastic has been found to be a very efficient lining for concrete tanks intended for use in leaching ores with a 10 per cent. solution of sulphuric acid. Experiments have shown that this material, after a year's test, showed no defects or deterioration and was the best of all materials tried for this purpose.

Davis Dearsenicator.[2]—A new dearsenicator, which differs from those now in use, the majority of which are of the tower type, is the Davis. In all the tower types the sulphuric acid falls down over lead grids of various shapes which are so designed as to offer a large area to the action of the precipitant, which is hydrogen sulphide. The maintenance of these is expensive and repairs are frequent.

The Davis dearsenicator consists of an iron drum which is separated into several sections. This is lined completely with a special enamel which is quite resistant to sulphuric acid up to a temperature of 200° C.

Inside each of these sections an enameled fan is placed so that about one-fourth of the blade dips beneath the level of the acid in the drum container. These fans are attached to a common shaft and are revolved at between 40 and 60 r.p.m.

The object of the fan is two-fold. It is designed to throw the acid up as thin sheets and spray which enables the hydrogen sulphide to act very

[1] *Met. Chem. Eng.*, May, 1914.
[2] *Met. Chem. Eng.*, May, 1914.

completely on the arsenic present in the acid. It also keeps the sulphuric acid in each particular section in constant agitation, preventing the settlement of the As_2S_3.

The vents in each section are so placed as to allow the acid to run from section to section until it reaches the outlet pipe, whence it passes to the filter tanks of special design where the As_2S_3 is completely filtered out.

The machine is remarkably efficient, giving a product containing 1.5 parts arsenic per million to 1 part arsenic per million parts sulphuric acid. It will do this starting with an acid containing as high as 0.5 per cent. of arsenic, at an average cost of 30 cents per ton for treatment.

It is claimed that acid made from pyrites and treated with H_2S in this manner is purer than acid ordinarily made from sulphur as all the lead, copper, antimony and bismuth are also completely removed.

Bibliography

Anon.—The Falding Sulphuric Acid Chamber. *Eng. Min. Jour.*, **95**, 318.

Briner E. and Kunhe, A.—Mechanism of the Formation of Sulphuric Acid. *Comptes rendu*, **157**, 448, 1913.

Wilkie, Wm.—Combination of the Contact Process with the Ordinary Lead Chamber or Tower Systems: An Improvement in the Manufacture of Sulphuric Acid. *Jour. Ind. Eng. Chem.*, 4, 840.

———————. Chief Inspector 49th Annual Report on Alkali, etc., Works. *Jour. Soc. Chem. Ind.*, Aug. 15, 1913.

TALC AND SOAPSTONE

By Frederick B. Peck

Chemically speaking, talc is an acid metasilicate of magnesium, having the formula $H_2Mg_3(SiO_3)_4$, where $SiO_2 = 63.5$ per cent., $MgO = 31.7$ and $H_2O = 4.8$. The minerals that most frequently alter to form it are tremolite which is a metasilicate of calcium and magnesium with the formula $CaMg_3(SiO_3)_4$, and enstatite, an orthorhombic pyroxene, also a typical metasilicate having the composition $MgSiO_3$. The magnesian mica, phlogopite, with the more complex constitution $H_2KMg_3Al(SiO_4)_3$ is occasionally found to furnish talc, though its natural alteration product would be serpentine.

Rock masses composed of one, two or all of these minerals, or to any considerable extent of them, furnish the most favorable starting point for the formation of deposits of talc on what usually proves to be a commercial scale. Tremolite by reason of its chemical constitution and the comparative frequency of its occurrence as rock masses in the crust of the earth, is by far the most common mineral to furnish talc, as may be judged from the following theoretical analysis.

COMPOSITION OF TREMOLITE.

Silica (SiO_2)	57.7
Magnesia (MgO)	28.9
Lime (CaO)	13.4

This process of alteration may be expressed thus:

$$CaMg_3Si_4O_{12} + H_2O + CO_2 = H_2Mg_3Si_4O_{12} + CaCO_3$$

where the tremolite, acted upon by water containing carbonic acid, is changed to talc by a leaching away of the lime and the replacing of that constituent by water.

Varieties of Talc.—In its purest and most typical form, talc is to be found as a crystallized mineral in seams and fissures where to all appearances it crystallized from aqueous solutions. This variety exhibits most clearly the distinctly micaceous habit of the mineral, showing a very perfect cleavage parallel to the basal pinacoid, by virtue of which it is easily separated into thin flakes or "foliæ" and hence is known as "foliated" talc. In its more massive forms where it occurs in larger quantities, it may also have more or less of this flaky, micaceous or foliated character.

When talc results from the alteration of large masses of tremolite or

enstatite, it is quite apt to assume a more or less distinctly fibrous character, the long axes of the talc fibers lying parallel to the prisms of the original tremolite or enstatite crystals. A microscopic examination of the altered tremolite rock mined at Talcville, N. Y., and largely used in the manufacture of the best grades of fibrous talc, shows the altered crystals to consist largely of an aggregation of distinctly asbestiform filaments to which the pronounced fibrous character of the talc is due. When used in the manufacture of paper this fibrous variety acts not only as a "filler," but on account of its fibrous nature adds materially to the strength and flexibility of the finished article. The chemical variation of talc is shown in the following few analyses of the material as found at some of the important producing localities both at home and abroad.[1]

ANALYSES OF TALC.

	SiO_2	Al_2O_3	FeO	MgO	CaO	H_2O	MnO
St. Lawrence Co., N. Y.	60.59	0.13	0.21	34.72	....	3.77	1.16
St. Lawrence Co., N. Y.	62.10	....	1.30	32.40	....	2.05	2.15
Hewitt Mine, N. C.	61.35	4.42	1.68	26.03	0.82	0.62	....
Lusenach, France	61.85	2.61	0.25	34.52	....	0.60	Na_2O, K_2O 0.17
Valley of Pignerolles, Italy	60.60	0.30	0.60	35.30	0.40	Not det.	

The massive, more or less impure form of talc, which usually results from the alteration of basic igneous intrusions of the pyroxenite or peridotite varieties, is technically known as steatite, but more popularly goes by the name of "Soapstone." Soapstone naturally varies considerably in composition, due to the fact that it results from the alteration of rocks of varied mineralogical composition. The minerals that naturally alter to talc are often but incompletely changed, leaving cores or fragments of the undecomposed minerals as hard gritty particles in the talcose matrix. The following analyses from five localities illustrate this variation.

ANALYSES OF SOAPSTONE.[2]

	SiO_2.	Al_2O_3.	FeO.	MgO.	CaO.	H_2O.	MnO.
Grafton, Vt.	51.20	5.22	8.45	26.79	1.17	6.90	0.32
Dana, Mass.	38.37	5.64	8.86	28.62	3.90	14.49	Trace
Baltimore Co., Md.	52.70	5.57	7.63	26.88	1.77	5.48	....
Lafayette, Penn.	33.47	0.45	7.38	33.72	1.34	23.00	0.21
Guilford Co., N. C.	40.03	10.86	9.50	26.97	1.70	10.78	....

Uses of Talc and Soapstone

The uses to which these materials are being put are so increasingly numerous, that it seems advisable to reconsider them.

A large percentage of the talc-rock mined or quarried the world over, is ground to a pulp or flour, the most conspicuous use of which is as a so-called "filler" in the manufacture of paper of almost every grade. Fibrous talc is particularly efficient in this capacity, because it adds mate-

[1] Merrill, "The Non-metallic Minerals," p. 205.
[2] Merrill, "The Non-metallic Minerals," p. 205.

rially to the strength and flexibility of the paper. All forms of ground talc, whether fibrous, foliated or massive, are preferred to any other kind of mineral filler, in that they impart superior whiteness, finish, opacity (a quality especially desirable in papers used in printing), and absorptive power (a quality also desirable in papers designed for typographic uses, where rapid and uniform absorption of the ink is necessary). Next to talc, white porcelain clay appears to give the best results as a mineral filler and in this country seems to be more commonly used. It gives neither the strength nor the flexibility that talc does and it is in other respects inferior to that mineral. Gypsum is also used for this purpose. In Austria-Hungary all attempts to manufacture Chinese absorbent paper and certain other forms of printing and fine art paper, failed until fine talc was used. In the manufacture of lithographic paper of superior quality, for art purposes, which must be suited either to the printing of the most delicate half tones or the deepest shades and heaviest colors, talc gives altogether the best results. In the process of manufacture it effects a more even distribution of the moisture, and facilitates the rolling, polishing and cutting of the paper. In all grades of paper where porosity and absorption are required, as in filter and blotting papers, talc by virtue of its high absorption, gives altogether the best results. It facilitates erasures and imparts a superior firmness and body to writing and drawing papers. In the manufacture of photochemic, map, wall, roofing, sheathing, advertising and wrapping papers, it is being used more and more.[1]

While the chief use of talc is in the manufacture of paper, it is becoming increasingly important in so many other ways that it would require more space than is at our disposal to consider them all in detail. Next to the manufacture of paper, perhaps the rubber industry absorbs the most talc. It is not only mixed throughout the body of many rubber products, but it is used to free the rubber from the molds. As an adulterant in cheap grades of soap it is used in considerable amounts. Another important use of talc is in the sizing of cotton cloth. It offers such high resistance to the electric current that it is of use in all sorts of insulators, such as the covering of electric wires. Considerable amounts are used in the manufacture of mineral and waterproof paints. As a foundry facing in the casting of iron it serves another purpose. One of the best-known uses of talc is in the manufacture of toilet powder, but most of the raw material consumed in its manufacture comes from Italy or France. Perhaps the form of talc that brings the highest price is the compact variety used in the manufacture of tailor's pencils, gas tips, and certain high-grade insulators.

Soapstone is used in large quantities in the manufacture of laundry

[1] "Mineral Resources of the United States," 1912. Articles by J. S. Diller.

tubs, and because of its resistance to chemicals, particularly acids, it is of special use in the manufacture of tanks and table tops for laboratories of every description, photographic, chemical and biological. For switchboards, panelling and flooring in electric plants it is admirably adapted because of its resistance to the electric current. With the advent of fireless cookers still another demand is made upon it, while soapstone griddles and foot-warmers are not altogether out of date. Wherever resistance to heat is desired, there soapstone serves an admirable purpose. For which reason it is much used for stove and furnace linings and facings while in some parts of the country the old-fashioned soapstone stove still survives. In short, the uses for both talc and soapstones are so numerous that one scarcely realizes at how many points they touch this modern age, or how much they contribute to our comfort and general well-being.

Production of Talc and Soapstone in the United States

The United States is not only the largest producer but also the largest consumer of talc and soapstone in the world. According to recent reports of the United States Geological Survey as published in advance sheets of Mineral Resources for 1913, the country's production of talc for 1913 was 149,271 short tons, having a value of $1,280,020 which was nearly 12 per cent. more in quantity and over 16 per cent. more in value than the production of 1912. The production of 1913 exceeded that of 1912 by 15,982 tons and in value by $182,537. The production of soapstone for 1913 in the United States was 26,562 tons, valued at $628,077 whereas in 1912 it was 25,981 tons, having a value of $609,480, which was a gain of 581 tons in quantity and $18,597 in value over the production of 1912. The production of both talc and soapstone in this country in 1913 was the greatest in the history of the industry, the combined output amounting to 175,833 tons in quantity and $1908,097 in value. The combined production of both talc and soapstone in 1912 was 159,270 tons valued at $1,706,963. The production of 1913 exceeded this by 16,563 tons, in value by $201,134. The following table shows the growing importance of the industry.

Imports.—Although producing much more talc than all of the other nations combined, the United States imports some of the finer grades from France and Italy, prices for which range from $15 to $25. Canada also supplies some. In Canada the crude rock is valued at $2 per ton at the mine while the ground material averages from $9 to $10 per ton, or about the same as the New York commodity. In 1912 the imports amounted to 10,989 tons and in 1913 to 13,770 tons.

The talc and soapstone deposits of the United States are found associated with the ancient crystalline rocks that form the axial portions of the mountain systems, which traverse the eastern portion of the continent from Alabama to New York and Vermont. Within this continental axis the rocks are intensely folded, faulted and sheared as is universally the case in these oldest of all visible portions of the earth's crust. These processes favor changes in rock masses and have played an important part in the formation of such mineral deposits as those we are considering. The original chemical and consequent mineralogical composition of the rocks was, of course, the controlling factor.

The talc-soapstone belt begins in northern Georgia near Chatsworth, Murray County, where basic igneous rocks of the peridotite variety, have been altered to talc and soapstone. The northeastern extension of the belt passes into North Carolina, crossing the extreme southeastern corner of Tennessee, and at Nantahala and Hewitts, south of Asheville in Swain County, attains its chief development in that state. From here it may be traced northeastward into Nelson and Albemarle Counties, Virginia, where for many miles it forms a rather continuous belt, the development of which has made the state the greatest soapstone producer of the union. Continuing northeastward into Maryland at Marriottsville, Carroll County, basic igneous rocks by alteration have once more produced both talc and soapstone on a commercial scale. The line of producing centers crosses the southeastern corner of Pennsylvania and ends so far as the Appalachian region is concerned on the Delaware river in Northampton County, Pa., where talc and serpentine have resulted from the metamorphism of tremolite rocks formed from ancient limestones and dolomites. The talc and soapstone deposits thus far considered are associated with the closely folded rocks forming the core or axis of the Appalachian system of mountains. Our further search for deposits of economic importance, consisting of talc or soapstone, takes us into another physiographic region and into the heart of another mountain system, the Taconic and Green mountain. In the northeastern corner of Massachusetts at the towns of Rowe and Zoar, Franklin County, are important deposits, from which points talc and soapstone can be followed more or less continuously northward the entire length of the state of Vermont. The most important of the talc-producing localities, however, lies northwest of the Adirondack region in northern New York. This section with the other more important ones will receive special mention later.

Market.—In spite of the complaints of business depression and a slight falling off in the production of certain localities, the production of talc and soapstone in the United States reached a climax in 1913, having far surpassed all previous records. Furthermore the demand particularly

for talc is increasing, and with the resources at our command so abundant, there is every reason to expect a steady growth of the industry. The concerns already in the field are aggressive in their methods and are anxious to meet the demands of consumers. The outlook for the future, therefore, is decidedly one of encouragement.

PRODUCTION OF TALC AND SOAPSTONE BY STATES.

	1909.		1910.		1911.		1912.		1913.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
New York	48,536	$359,957	71,710	$728,180	62,030	$613,286	66,867	$656,270	81,705	$788,500
Vermont	23,626	120,329	25,975	136,674	29,488	200,015	42,413	275,679	45,547	327,375
New Jersey and Pennsylvania	13,900	61,967	13,192	62,833	12,131	54,319	10,400	50,519	11,308	80,780
Virginia	26,511	523,942	25,908	519,781	26,759	660,926	25,313	576,473	26,487	615,558
Massachusetts	9,057	48,729	7,475	52,204	7,642	36,883	.....	.....	.....	.....
North Carolina	5,956	77,983	3,887	69,805	3,548	57,101	3,542	63,304	4,676	48,817
California	.....	.....	.....	.....	.....	.....	1,169	15,653	952	6,000
Other States	.....	.....	.....	.....	.....	.....	9,566	69,065	5,158	41,067
Total	.....	.....	.....	.....	.....	.....	159,270	1,706,963	175,833	1,908,097

Talc only	California and New York.
Talc and soapstone	North Carolina, Vermont and Virginia.
Soapstone only	Rhode Island.
Talc and serpentine	New Jersey and Pennsylvania.
Pyprophyllite	North Carolina.

California.—In 1912 there were four producers, while in 1911 there was but one. The concerns are located, one near Lindsay, in Tulare County, the other in San Bernardino and Inyo Counties, between Silver Lake and Death Valley. During 1912 the increase in production was greater than in any other state but during the year there appears to have been an overproduction, for the stock was not all absorbed by the trade. Production for 1912 was 1169 tons whereas in 1913 it was but 952 tons.

Recent investigations of these deposits by the United States Geological Survey, the results of which are published in the report of J. S. Diller in Mineral Resources for 1913, mention the exceptional whiteness of the talc. As in New York the talc results from the alteration of tremolite schists. The following table compiled from the publications above mentioned, shows the relative importance of the various states as producers.

New York.—For many years New York has been the leading producer of talc, and until 1907 furnished more than one-half of the total production of the United States. Since that date some of the other states, notably Vermont, have been coming rapidly forward. In 1913 New York reached its high-water mark, of over 80,000 tons, exceeding by 10,000 tons its previous annual record, attained in 1910, which amounted to 71,710 tons. This increase appears to be due to the development of three new properties. One of these new mines is operated by the Union Talc Co., and is known as the Wight mine. Development of this property began in 1911, and it

has since been operated continuously. It is located 1 1/2 miles south of Fowler and 6 miles southeast of Gouverneur. The structure in the rock masses here strikes northeast and southwest, and dips northwest at an angle of 33°. Four beds are known to exist within a thickness of 200 ft. measured across the beds. The new opening is in the lowest bed and consists of a slope inclined at an angle of 33 deg. and is 150 ft. long. Two levels have been started, the lower at 140 ft. is 125 ft. long and proves the talc to have a thickness of 25 ft. Some of the talc is beautifully white and is of the foliated variety, and occurs in quantities large enough to suggest the possibility of the manufacture of a special grade. In this greatest of all talc-producing sections of the world, another of the recent developments is located near Talcville, and consists of a mine and mill owned by the Uniform Fibrous Talc Co. This mine also began producing in 1911, and greatly increased its production in 1912. It has a hydro-electric power plant of modern design, a fireproof steel and concrete mill equipped to half its capacity with conical and cylindrical pebble mills, such as have proved most efficient in grinding the rock of that region. A 200-ft. shaft has discovered a large body of talc the dimensions of which can only be determined by future development. The greater portion of it is of the fibrous variety and is admirably adapted to paper-making, while parts of it are foliated.

The third new venture in the talc-producing line lies 15 miles southwest of Gouverneur near Natural Bridge. The property is being developed by the St. Lawrence Talc Co. The mill is equipped with crushers, a conical pebble mill, Newago screen, and one or more long cylindrical pebble mills, and is being operated by electrictiy. The talc body which has very irregular walls is over 20 ft. thick and of unknown length. It is associated with serpentine, limestone and gneiss, and is rather highly aluminous. The talc body has been opened by a shaft over 100 ft. deep, which has been widened by an incline at the top so as to deliver the rock to the mill. This mine began operations in 1912.

New Jersey and Pennsylvania.—The producing sections of these states are contiguous and may therefore be considered together.

No recent developments can be reported from this section. For many years three companies have been producing ground rock, viz., C. K. Williams and Co., paint manufacturers, with one quarry and two mills in operation at Easton, Pa.; D. D. Wagner and Co., one quarry and mill also at Easton, Pa., The Lizzie Clay and Pulp Co., operating a quarry and mill in the vicinity of Phillipsburg, N. J. In all of these instances the rock used in the manufacture of mineral pulp is in part serpentine and in part talc, or more accurately speaking, tremolite partly altered to talc. The serpentine results chiefly from the alteration of a color-

less pyroxene and the brown magnesian mica phlogopite which occurs in large crystals or in rather finely granular aggregates. All three of these minerals, viz., the tremolite, the pyroxene and the mica, which on alteration furnish the serpentine or the talc, were built up in ancient highly crystalline, magnesian or dolomitic limestones, which are among the important precambrian rocks of New York and New Jersey, and which in northern New Jersey have been mapped as the Franklin Furnace limestones. In going southwest from Franklin Furnace the type locality, these limestones thin out and disappear at the Delaware river. In fact the talc-serpentine rocks of the Easton-Phillipsburg region are the altered remnants of this precambrian limestone.

North Carolina.—While not a large producer of talc, North Carolina produces the most expensive grades of talc mined in the United States. In 1912 the production was 1573 tons valued at $50,453, the price per ton being about $32. This is far in advance of the market price of the best grades of fibrous talc from New York, which sells for about $10 per ton. The very compact character of mineral gives it its value, this property being required in the manufacture of pencils and gas tips. The talc producing localities lie in the western part of the state in Cherokee, Jackson and Swain Counties, there being four producers in all. A small amount of soapstone is produced in Alleghany County.

Pyrophyllite.—North Carolina is a producer not only of talc and soapstone but also of another mineral having very similar physical properties to talc. This mineral, pyrophyllite, is a hydrous silicate of alumina, and is quite different chemically from talc. Its composition is expressed by the formula Al_2O_3, $4SiO_2$, H_2O, where $SiO_2 = 66.7$, $Al_2O_3 = 28.3$ per cent. and $H_2O = 5.0$ per cent. It is used instead of talc for almost all purposes that mineral serves, but does not command as high a price as the best grades of talc.

There are three companies operating at present, the Southern Talc Co., the Deep River Talc Co., and the Glendon Mining and Manufacturing Co. They are all located near Glendon, Moore County, within a half mile of each other. The Glendon Mining and Manufacturing Co. is operating on the largest scale. Open-cut methods are mostly employed in taking out the rock, which occurs in beds of considerable thickness in slate, associated with quartz and pyrite. In 1912 more pyrophyllite than talc was produced, 1696 tons of the former valued at $12,851 being reported, while the production of the latter amounted to 1573 tons, valued at $50,453.

Rhode Island.—In even a cursory review of the talc and soapstone industry, Rhode Island should receive passing mention. There is one quarry in the state at Manville, Providence County, operated by the

Rhode Island Soapstone Co., which supplies a local demand for soapstone, the production of which, though small, increased 20 per cent. in 1912.

Vermont.—For the past few years Vermont has been increasing its output and for the last 4 years has held second place. Both talc and soapstone are found in numerous localities to the east of the Green mountains. In but few instances, however, are the deposits being developed, there being but eight active mines and quarries in the state.

Deposits of talc worthy of note are to be found near Windham, Bridgewater, Roxbury, Lowell, Duxbuy, Moretown, Rochester, Granville, Stockbridge and Johnson. It is usually massive in character though occasionally the foliated variety is present in inconsiderable amounts. The New England Talc Co. at Stockbridge has recently completed a new mill. For a number of years talc has been mined at east Granville, Rochester and Johnson. At east Granville the talc is reached through a shaft 100 ft. deep. At Johnson the deposit has been rather extensively developed by the American Mineral Co. where a mine and mill are in active operation, and to the east of Rochester is the plant of the U. S. Talc Corporation, another of the really important producers of the state, with a mime and mill in active operation.

Soapstone is more abundant than talc in Vermont, and until recently has been more extensively mined. In the early history of the development of the industry it was used as structural material, window caps and sills, doorsills, hearths, stoves, being made of it, while more rarely entire buildings were constructed of it. Extensive beds of it occur at Cavendish, Grafton, Chester, Weathersfield and Athens. Three miles southwest of Chester the Union Soapstone Co. has 2 quarries, one 70 ft. wide, and 30 ft. deep, the other 100 ft. long by 70 ft. wide and 60 ft. deep. The beds here take the form of overlapping lenses, which are from 2 to 4 ft. thick, and 20 to 30 ft. in width. The enclosing rock is gneiss. The beds are quarried with channelling machines and by wedging, and the blocks are taken to the company's mill at Chester where they are sawn, planed, turned and grooved in preparation for the manufacture of tubs, sinks, etc. The waste from the mill is ground and used in the making of paper, paint, wall-finishing material, etc. Two and one-half miles northwest of Chester, near Ludlow, the American Soapstone Finishing Co. is operating a mine and mill, the product of which is similar to that of the Union Soapstone Co. At Weathersfield soapstone has been quarried for more than 60 years and used in the manufacture of tubs and sinks. It was here that wood stoves were formerly manufactured in large numbers.

Virginia.—While Virginia ranks fifth in the production of talc, it

easily holds first place as a producer of soapstone, producing not only many times more than the other states, but more than all the rest of the world. In 1913 the production of soapstone in the United States was 26,562 tons, considered to have a value of $628,077, which was a gain of 581 tons in quantity and $18,597 in value over the production of 1912, for which Virginia appears to be largely responsible. There are seven producing concerns, the Old Dominion Soapstone Co., the Virginia Soapstone Co., the Phoenix Co., the Piedmont Co., the Bull Run Talc and Soapstone Co., John B. Holt and Son and the Cuthbert Land and Development Co.

The Virginia Soapstone Co. seems to be the chief producer, with two mills, one at Schuyler and the other at Alberene. The quarry which supplies stone for both is at Alberene, Albermarle Co. The rock, probably altered peridotite, strikes north 35° east and dips 35° to 55° to the southeast. Five quarries have been opened from time to time along the strike for a distance of 500 ft. The quarry being operated at present is 128 to 157 ft. wide which is about the entire width of the belt. One of the older quarries was excavated to a depth of 200 ft. which is the limit of profitable quarrying. The more recent developments are located at the southern end of the belt in Nelson County, where the Phoenix and Piedmont quarries are in operation. Here the general relations of the beds are the same as farther north. Lack of railroad facilities seems to be the chief drawback. From Phoenix to Alberene, a distance of 25 miles, the beds have essentially the same position, and form a more or less continuous belt.

PRODUCTION OF TALC AND SOAPSTONE BY COUNTRIES.
(In tons of 2000 lb.)

	U. S. (a)	France. (b)	Italy. (c)	Canada. (c)	Spain. (d)	Austria. (c)	Ger. Empire, Bavaria. (d)
1905	96,634	25,956	7,154	500	4,810	.....	2,064
1906	120,644	29,061	9,624	1,234	3,978	.....	2,131
1907	139,810	38,262	13,574	1,534	15,294	.....	2,203
1908	117,354	37,053	12,048	1,016	5,214	.....	2,424
1909	130,338	38,433	13,228	4,350	6,154	.....	2,567
1910	150,716	42,316	13,727	7,112	5,143	.....	3,398
1911	143,551	44,092	15,600	7,300	6,226	15,212	3,782
1912	159,270	(e)	13,580	8,270	(e)	(e)	3,551
1913	175,833	(e)	(e)	12,250	(e)	(e)	(e)

(a) Talc and soapstone. (b) Talc, soapstone and asbestos. (c) Talc. (d) Soapstone. (e) Statistics not available.

A glance at the foregoing table compiled partly from Mineral Resources of the United States for 1912 and 1913, and partly from MINERAL INDUSTRY, shows the United States to be far in advance of other nations in the production of talc and soapstone. In the case of Canada the rapid development of her talc industry is but one indication of the rather phenomenal agricultural, industrial and economic development that is sweeping over the entire Dominion.

TIN

By Edward K. Judd

The most noteworthy features of the tin industry in 1913 were: (1) a marked decline in prices toward the end of the year; but as the tin market is notoriously speculative, and as consumption shows no likelihood of diminishing, there is little reason to apprehend a relaxation of active search for additional supplies. (2) Discovery of new tin fields in Australia, and increased yield from Central Africa. (3) Increasing importance of operations conducted on a large scale by modern methods in the Malay States and Siam; new hydraulic dredges are being installed at numerous places, and great areas of tin-bearing gravel formerly neglected are being profitably exploited. Modern methods are also being introduced into Yunan province of China.

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1902..	85,043,353	$21,263,337	1906.	101,027,188	$37,446,508	1910.	105,137,740	$33,921,449
1903..	83,133,847	22,265,367	1907.	82,548,838	32,075,091	1911.	106,936,872	43,390,639
1904..	83,168,657	22,356,896	1908.	82,503,190	23,932,560	1912.	116,003,385	50,371,102
1905..	89,227,698	26,316,023	1909.	95,350,020	27,559,937	1913.	104,282,230	46,900,314

Tin Mining in the United States

According to the U. S. Geological Survey, the production of tin ores during 1913 was equivalent to about 50 tons of metal, and came from five widely scattered localities, three in Alaska, one in South Dakota, and one in South Carolina.

In Alaska the York Dredging Co., working on Buck creek, about 15 miles east of Cape Prince of Wales, produced 65 tons of stream tin carrying approximately 68 per cent. of tin. The dredge ran only six weeks, a dry season preventing longer operation.

On Lost river, 20 miles south of Buck creek, the Jamme Syndicate, in order to test the ores from the lodes at that place, put up an experimental concentrating plant, in which 49 tons of ore gave 5000 lb. of concentrates carrying 62.5 per cent. of tin and 11.1 per cent. of tungsten. The company is said to have developed a considerable quantity of similar ore and to have larger plans for future work. On Brooks Mountain, a

few miles east of Lost river, prospecting was done during the year but no tin was produced.

It is reported that on Sullivan creek, near Hot Springs, on the south side of lower Tanana river, Alaska, about 2 tons of stream tin was taken out during the summer. In the Sullivan creek district, the area in which the cassiterite occurs in small, being less than a mile in its longest direction. The stream tin varies in amount with the gold, the placers commonly being rich or lean in both minerals. In the richest spots as much as 1/2 lb. of cassiterite to the pan is reported. Gravels that contain as little as 9 lb. of cassiterite to the cubic yard are being mined profitably in the York region, Alaska. There can be little doubt that a great part of the gravels mined on Sullivan creek carry as high a content of tin as this and that some may run much higher. However, on account of the inconvenience that the tin ore occasions in the extraction of gold, the tin is regarded as a nuisance by the miners of the district rather than as a possibly valuable product.

From the vicinity of Tinton, S. D., a little more than a ton of concentrates was shipped. At Gaffney, S. C., the Cherokee Tin Mining Co. took 5700 lb. of cassiterite out of residual placers; the product carried 71.5 per cent. of tin and was sold for 34 cents per lb. of concentrates. The company did some prospecting by drilling and expects to work the lode. The old gneisses forming the country rock in which pegmatities carrying cassiterite have been intruded are so disintegrated that they can be worked by pick and shovel for many feet in depth.

In North Carolina, the Piedmont Tin Mining Co. did some development and prospecting work at Lincolnton, but made no production.

Secondary Tin in the United States.—According to the U. S. Geological Survey, the amount of secondary tin recovered in 1913 was equal to 27.2 per cent. of the tin, as metal or as oxide, imported into the United States during the year (52,141 short tons). Secondary tin recoveries decreased from 15,401 tons, valued at $14,301,368, in 1912, to 14,178 tons, valued at $12,567,379, in 1913. The quantity recovered as metal was 6415 tons and that in alloys and chemical compounds 7763 tons. It will be noted that the secondary tin in alloys increased about 700 tons, an increase similar to that of lead in alloys. The secondary pig tin decreased about 1900 tons, for although the reports showed that the recoveries from scruff and drosses compared favorably with former years, the recoveries from clean tin scrap, tin foil, and tin pipe were appreciably less in 1913 than in 1912. This condition was natural, for the use of tin foil and block-tin pipe has not expanded and the recoveries from those sources are relatively small. The quantity of clean tin scrap treated was considerably less in 1913 than in 1912. This was partly due to the burning of the

Vulcan Detinning Co.'s electrolytic plant at Sewaren, N. J., and to decreased operations of several other users of clean scrap tin. There was no great incentive to treat tin scrap which had been contracted for or purchased at prices that precluded much profit at the prevailing lower prices of pig tin in 1913.

The recovered tin includes the tin contents of products made by several plants from tin scrap. These included some tin oxide, putty powder, etc., but consisted mainly of tin chloride. As the products are made from scrap tin and thus conserve the primary metal, they are properly regarded as recovered tin.

The principal alloys in which secondary tin was recovered were babbit and other bearing metals, bronze, solder, pewter, and electrotype metal.

PRODUCTION OF TIN METAL IN THE WORLD.
(In metric tons.)

Country in which smelted.	1908.	1909.	1910.	1911.	1912.	1913.
Australia(*m*)	6,700	6,450	5,500	5,150	5,130	3,071
Austria-Hungary(*a*)	39	52	39	16	14	13
Banka, sales in Holland (*m*)	11,710	12,150	13,631	15,147	16,111	.....
Billiton, sales in Holland and Java (*m*)	2,270	2,280	2,240	2,240	2,243	2,241
Bolivia, metal exported to England(*w*)	1,174	834	1,003	464	552	.....
China, exports(*a*)	4,836	4,516	6,510	6,056	8,785	3,889
France(*m*)	*Nil.*	*Nil.*	*Nil.*	500	.....	.....
Germany, mainly from Bolivian ores(*a*)	6,374	8,995	11,394	12,426	10,646	.....
Japan(*a*)	26	23	23	155	36	.....
Straits Settlements, exports (*m*)	63,690	61,540	57,490	57,944	62,783	66,376
United Kingdom, from domestic ores(*a*)	5,133	5,282	4,874	4,950	.....	.....
United Kingdom, from imported ores(*m*)	11,614	11,890	13,055	13,850	13,886	.....
Total production of metal	113,566	114,012	115,759	118,898	.....	.....

(*a*) Official statistics. (*e*) Estimated. (*m*) *Metallgesellschaft.* (*w*) Watson & Co.

NOTE.—Among the more important omissions from the above table, due to imperfect statistics, are the following: (1) Output of native smelters in Central and South Africa; (2) Exports from Siam and the Dutch East Indies to India, China, Korea and Japan; (3) Local consumption in Straits Settlements, Siam and Dutch East Indies.

TIN MINING IN FOREIGN COUNTRIES

Africa.—In response to the demand for new supplies of tin, active exploration has been under way for a number of years, and in some of the producing districts a substantial and dependable output has been established. The importance of the latest discoveries has been recognized also by the economic geologists, who during 1913 recorded the ore occurrences in a number of districts with considerable detail.

Belgian Congo.[1]—Mining rights in Katanga are practically owned by the Belgian *Comité Special,* which retains 33 per cent. interest in any concern formed in that district, and an option to subscribe to an additional 20 per cent. Although the Belgians thus control the management of all mining enterprises in the country, owing to the extensive area on which

[1] R. H. Gwyn-Williams, *Min. Jour.*, Aug. 23, 1913.

mining developments have been begun it is likely that foreign capital will be given an increasing opportunity to enter the district.

The company now operating these mines is using a battery of five 600-lb. stamps, crushing 4 to 5 tons per day per stamp through a 1-cm. screen; although this crushing is coarse, over two-thirds of the total tin contents are found in the material passing through a 0.3-mm. screen, which indicates that some more suitable crushing method should be adopted. The crushed cassiterite is separated in sluices, jigs, and pans, about 300 of the latter being at work. Each pan recovers 1 1/2 to 2 kg. of concentrate per day, containing 55 per cent. Sn, at an average cost of 14 cents per kg. Alluvial and decomposed lode ore are screened, the coarse being panned, and the finer concentrated on a Wilfley table. The tailings from all parts of the operation are being saved for subsequent hydraulic working. At present, the company is producing cassiterite concentrate at a cost of 1400 fr. per ton; freight from Kiambi to Antwerp is 250 fr. The company intends to enlarge the present plant, and to extend its operations on the alluvial deposits of the neighborhood.

At Kasonso, in the southeastern part of the Congo, a tin field owned by the Union Minière du Haut-Katanga was thoroughly tested by a party of European engineers and Chinese tin miners from the Malay States; this district will shortly be benefitted by the building of the Elisabethville-Bukama railway.

Nigeria.—The output of concentrated tin ore in 1913 was nearly double that of the preceding year, the growth of the industry within the past 7 years being indicated by the following figures from the British Colonial Office: 1907, 175 long tons; 1908, 514 tons; 1909, 253 tons; 1910, 774 tons; 1911, 1471 tons; 1912, 2886 tons; 1913, 5130 tons. It is impossible to state the metallic contents of this ore, but the Royal Colonial Institute records that the 1911 output was worth £189,174; 1912, £380,284, 1913, £500,000. Imports of Nigerian tin-ore concentrates into the United Kingdom during 1913 were 3825 tons, against 2450 tons in 1912. Pending the completion of official surveys, the tin-bearing area between 8° and 9° 45′ east longitude, and between 9° and 11° 15′ north latitude, was closed to prospecting grants in November, 1912; the finished maps were expected to be published early in 1914. The largest and most regular producers were the Bisichi, the Forum River, the Jantar, the Kaduna, the Naraguta, the Naraguta Extended, the Bauchi, the Rayfield, and the Ropp Cos.

South Africa.—A small production of alluvial tin is still being made from the Kuilo river district near Capetown, Cape Colony. The Swaziland deposits are now being prospected by Empire drills and the deposits worked by modern methods. Several hydraulic elevators are

now at work and electric elevators are being introduced to economize water power in elevating tailings. The Swaziland Tin, Ltd., is now producing about 40 tons per month with a profit of $4000. The deposits are not extensive and have had their richest portions worked for a total yield of about £300,000.

To the north of Pretoria, Waterberg tin fields continue to make large returns. The Zaaiplaats mine, working irregular pipe deposits and impregnations along fissures, is returning about 100 tons of concentrates per month at present and proves a favorite gambling counter, as litte ore can be developed and the ore-bodies are most irregular; one deposit has been followed for 1500 ft. on incline. The neighboring Groenfontein mine has run out of rich ore in all its pipes and practically ceased production. In the felsite area bordering the granite, the South African tin mines have been producing 2 per cent. ore and running a 10-stamp mill with indifferent results. The ore occurs in fissure veins and disseminated. The Welquarden mine has developed 20,226 tons of 2.7 per cent. tin ore and is erecting a small mill. Some of this ore is as fine as flour and the SnO_2 is a light yellow color.

In the quartzite area, the Rooiberg mine produced 70 to 90 tons of concentrates per month and is making large profits; developments are apparently satisfactory. The probable and developed ore was recently estimated at about 90,000 tons. The neighboring farm of Leeuwpoort was prospected by several syndicates without result, but the present company holding it has over 120,000 tons of 2.29 per cent. metallic tin developed, valued at from £300,000 to £400,000. An incline on the Spirit vein is down 652 ft. Old workings characterize this district. A mill to treat 4500 tons of ore per month is under construction at this mine.

Some further promising discoveries have recently been made on the Olefants river in the Cow Country of the Eastern Transvaal.

Australia.—A number of new developments were made during 1913 in various parts of the commonwealth, and although the earliest reports in some cases were widely exaggerated, it seems probable that an important addition to the world's supply may be expected from this quarter.

New South Wales.—While the majority of the tin ore obtained in this state is recovered by dredges, the largest of which are in the Emmaville and Tingha divisions, particular attention was given in 1913 to the development of lode deposits of tin ore, and deeply buried alluvial beds of stream tin.

The Ardlethan tinfield,[1] which dates from April, 1912, is situated

[1] W. C. Walworth Pearce, *Austral. Min. Stand.*, Mar. 6, 1913.

250 miles west by south from Sydney, and 40 miles southwest from Wyalong. Ardlethan itself is a small agricultural township, on the Temora-Barellan branch line, and is 337 miles by rail from Sydney.

The tin mines begin at about 3 miles northwest, there being an easy road all the way. The country is mostly granite; slate and other metamorphic rocks exist, especially on the eastern side, but the tin deposits are generally in the granite. The country is a rolling plain, devoid of running water. A great deal of the tin area is simply wheat fields; it is noticeable that most of the discoveries are on the low ridges or knobs. The area is nearly all freehold, and mining titles come under the Mining on Private Property Act, the method being to get a permit to enter, and later, if prospects warrant it, a lease.

Starting from the township, the first ore-producer is the White Crystal. There are three shafts, each on a separate pipe of ore, besides some trenches and pot holes. The quality of the ore is good, but the pipes seem small. A little further northwesterly is the Carpathia. The chief workings consist of an open cut, and a shaft at the northern end of the cut. The open cut shows an ore-body having a westerly dip. The outcrop of this ore-body was characterized by boulders of iron-coated ore, and led the belief that it was all iron. The ore-body is 12 or 15 ft. wide, and 40 or 50 ft. long; the gangue is kaolin and kaolinized granite. It is plainly a lense or pipe of the larger size; fine tin is well distributed through the earthy ore.

About 700 yd. west of the Carpathia is the Wild Cherry; the workings consist of a shaft on a pipe of ore, some of which is very rich and some needs picking. Further on is the Homeward Bound, which has two shafts about 150 ft. apart; these are 40 to 50 ft. deep. About 5 miles north of the Carpathia ridge is the Bygo district, and various prospecting pits have been opened in this direction. The Big Bygo has three or four pipes. The ore-bodies seem to be impregnations around cracks, and although of small size yet some very good ore has been raised.

In the majority of cases the prospect shaft takes in the whole extent of the ore-body or pipe; generally the pipes dip not far from vertical. The richest ore has been sent to Sydney; the bulk is, however, going to Wyalong, where it will be crushed in a stamp battery and dressed over Wilfley tables.

A report on the recently discovered tin field at Conapaira, 50 miles west of Wyalong and northwest of Ardlethan, has been made by J. B. Jaquet, Chief Inspector of Mines of New South Wales. The prospectors' claim, near the northern end of the field, was first opened as a gold mine a few years ago. Very little gold was found, though the wolfram attracted attention, and the mine was abandoned for several years. Early in 1913

it was re-opened, following the important discovery of tin at Ardlethan, and tin was found in association with the wolfram.

The ore consists essentially of quartz with cassiterite, wolfram, and pyrites. The latter mineral is present in insignificant quantities and frequently absent altogether. The amount of prospecting already carried out is insignificant, and has been mainly in the direction of locating the outcrops of the ore deposits. In some places the country is decomposed and easy to work for a considerable distance downward, but more often hard granite is encountered close to the surface. The majority of the mines are therefore not well adapted for exploitation by poor prospectors, and can be proved and developed only by the expenditure of considerable capital. The development of the field has been hampered by lack of water. It is reported that arrangements have been made for the erection of a battery and concentrators at an early date.

At the Hargrove tin mine, 10 miles from Inverell, three separate leads in the granite converge in deep ground capped by basalt, which is supposed to be the outlet of the Hory and O'Rorke lead, which in the past has yielded a heavy output of tin oxide. The Hargrove alluvial stuff yields from 25 to 200 lb. of clean tin oxide per load of 16 cu. ft., the ore being of excellent quality.

Other recent developments in New South Wales have occurred at Reedy Creek, 12 miles from Tarago, on the Braidwood road, and at the Arramagong mines, 10 miles from Grenfell, where both lode and alluvial tin are found. At Emmaville renewed attention is being devoted to the so-called "deep leads," that is, river channels buried under a maximum of 200 ft. of basalt or laterite. Another recent discovery is reported from Red Hill, between Young and Temora.

Northern Territory.—It was reported late in 1913 that a new tin field had been discovered at Beswick Creek, and it was expected that the House of Representatives would vote £8000 for the erection of a battery at Marynboy. Beswick Creek is 75 miles from Pine Creek, the terminus of the railway. Past experience has taught that the occurrence of tin ore in the Northern Territory is erratic, with the exception of Mount Wells. The introduction of a portable crushing plant on the West Arm fields was a complete failure.

Queensland.[1]—The commercial production of tin in Queensland dates from 1872, when the Stanthorpe field began to be exploited. It is distant about 4 miles from the southern border of the State, although the distance by rail is 24 miles. Before a year had elapsed the tin mining industry was in full swing. From the opening of the mines in April, 1872, to the end of May, 1875, were obtained 14,165 tons of ore, worth £715,330.

[1] *The Mining Journal*, June 28, 1913.

During the following 5 years the amount was about 16,000 tons, realizing £800,000, the price of the metal fluctuating during the period. The lowest price for this ore at Stanthorpe was in 1878, when it was down to £26 per ton, a rate which, operating with a gradual exhaustion of the cheaply won ore, almost extinguished the tin mining industry in the locality. Since 1881 the Queensland production has been as follows:

	Tons.	£.		Tons.	£.		Tons.	£.
1881	3,456	193,699	1907	5,140	496,766	1911	3,091	307,847
1891	2,236	116,387	1908	4,825	341,566	1912	3,230	364,503
1901	1,661	93,723	1909	3,326	244,927	1913	3,197	343,669
1906	4,823	490,283	1910	2,953	243,271	....	.....	.....

In 1913 the outlook in the Herberton district—now practically the leading source of the Queensland tin supply—was regarded as most encouraging. Two mines at Sunnymount have attracted attention, the Tommy Burns and the Prince Alfred. The extensive stanniferous area south of Cooktown, with its numerous water-courses and comparatively regular rainfall, is demanding wider recognition than it has hitherto received. The owners of the Lode Hill property, with its never failing water-power derived from the Upper Bloomfield, produced tin worth £5350, and in the same district the Roaring Meg Hydraulic Co. also had a successful year. The Annan river tin mines at Rossville gained the first results of their large expenditure in renovating and refitting their race, and in proving and testing the additional areas recently acquired by them. Tableland, Mount Amos, and the long-established Mount Romeo center all furnished increased outputs. Considerable quantities of stream tin have been obtained in the vicinity of the Croydon goldfield.

The chief center of lode tin mining is Stanhills. Two of the mines at Stanhills are considered of great prospective value, and it is thought probable that a true lode of great magnitude will yet be discovered, the country for miles around being stanniferous and displaying boulders of rich tin ore, presumed to have been detached from some large body.

A new tin discovery in the sandstone copper-bearing belt of country, 1 mile from Herberton, in which is situated the Anniversary copper mine, has created local excitement, as tin was never located in this locality before. The ore on the surface is exceptionally rich, and a strong syndicate has been formed to work the ground.

Tasmania.[1]—The northeastern portion of this state has been an important tin-producing center for over 30 years. It is reached from Launceston by railroad terminating at Branxholm, a distance of 71 miles. The Arba Tin Mining Co. is working a "lead" 400 ft. wide at the bottom and covered by 60 to 80 ft. of overburden. Drilling of 186 holes proved

[1] Abstracted from Peter G. Tait, *Min. Sc. Pr.*, Oct. 18, 1913.

750,000 cu. yd., averaging 1.9 lb. tin per yard. Two plants are at work, one with a 12-in. Austral Otis pump and a 10-in. gravel pump, and the other with a 12-in. nozzle Thompson pump. The depth of the ground now being worked is 139 ft. below surface, and the cost of haulage is 1.5 cents per cubic yard. In the last half of 1912, 49,161 cu. yd. of overburden was removed at a cost of 11 cents per cubic yard, and 73,440 cu. yd. of drift yielding 0.936 lb. of black tin per cubic yard at a cost of 13 cents per cubic yard.

The Briseis Tin & General Mining Co. is working a sub-basaltic river bed, the ancient channel of the Ringarooma river. In order to work the northern portion where the lead has been traced for a distance of 1000 ft., it was necessary to divert the Ringarooma river, and also the main Derby Moorina road. This ground was originally thought to be too poor to be profitable, and was consequently used as a dumping ground for tailing. Up to the present it has produced 730 tons of tin, an average yield of 3.5 lb. per yard. The official estimate at the end of December, 1912, gives a total of 800,000 cu. yd. remaining to be extracted, and the yield of tin as 750 tons. These are the main workings at present, and the depth of the ground is about 70 ft., but as work progresses the depth increases. The new road has been completed some time, and the river diversion work is well advanced. This will give several years' work following the lead under the bed of the modern river.

On the Ringarooma hill the difficulty is in the removal of the basaltic overburden. Sluicing is principally adopted. A certain amount of tramming is necessary for the heavier stones. Up to the end of 1911, the total amount of Ringarooma overburden removed was 1,525,500 cu. yd., at an average cost of 12 cents per yard. Tailing from the sluice-boxes is stacked by a 24-in. belt-conveyor, 130 ft. long, working at 33 per cent. grade, and stacking 50 yd. per hour. The mine is worked entirely by water-power. To May, 1913, the black tin (74.5 per cent. metallic) output has totaled 7075 tons, and dividends on the capital of $2,880,000 are $1,440,000. The tin is smelted at the Mt. Bischoff Tin Mining Co.'s plant at Launceston.

The Pioneer Tin Mining Co., Ltd., is operating on one of the tributaries of the main lead, and, as the overburden is not very heavy, the property can be worked much more economically than, for instance, the Briseis mine. Although the ground is comparatively friable, in places the cement is 40 ft. thick, and has to be blasted. It varies in depth from 40 to 120 ft., and four plants are installed, two steam, one of 400 and one of 220 h.p., and two electric, each of 400 h.p., with 16-in. pumps. From 1900 to 1913, there has been handled 5,396,900 cu. yd. of drift, yielding 4526 tons of black tin, equal to 1.878 lb. per cubic yard, at a cost of 13.5 cents

per yard. The company's capital is $960,000, and dividends total $1,180,000.

The South Mount Cameron company is working terrace ground on top of a ridge about 100 ft. above the Ringarooma, and the problem is to bring water to the ground. For this purpose a power-plant was built on the banks of the river. Water is delivered on the face at a nozzle pressure of 60 lb. by a Mather & Platt pump of 3500-gal. capacity per minute, against a head of 275 ft., driven by an Allen 400-h.p. engine. The ground is up to 15 ft. in depth, and of an average value of 1 to 1.5 lb. per yard.

The Clifton tin mine is at the foot of South Mount Cameron, and within a mile of the post town of that name, on the Branxholm—Gladstone road. The plant consists of a 12-in. gravel pump and 12-in. nozzle pump, driven independently. Both are of Austral Otis Co.'s manufacture. The engine is by W. H. Allen, Son & Co., and is of 150 h.p. capacity, operated at a pressure of 150 lb. The pressure at the nozzle is only 25 to 30 lb. per square inch.

The ground being worked is about ten chains wide, between granite on the one side and a soft pipe-clay formation on the other. There is an overburden of 15 to 20 ft., and the wash is in a comparatively narrow bed of 2 up to 9 ft. The whole ground averages 1.25 to 1.5 lb. per cubic yard.

The Anchor tin mine, at Lottah, is a large low-grade property, owned by a London company with a nominal capital of $336,000, of which $148,800 has been paid up. Two mines are being worked, the Anchor and the Australian mine, formerly owned by the Australian Blue Tier Tin Co. All the work is by open-cuts. At the Anchor the principal faces are known as the Pentridge, Haulage, and Tunnel faces, respectively. At the Pentridge face, the overburden, consisting of decomposed granite, is almost 80 ft. in depth, and necessitates sytematic arrangements for its removal. The Australian mine at Blue Tier is about 1500 ft. higher in elevation than the Anchor mine and on the side of a steep hill. All the ore from this mine is transported to the Anchor mill by a Pohlig aerial tramway having a length of 1.75 miles. The mill consists of two plants, each containing 50 stamps. No. 1 plant is working solely on Anchor ore, as also are 30 head of the No. 2 plant, the remaining 20 head being on the Australian ore. All the plant is driven by water power, and the company has a ditch of 39 miles in length.

The Gladstone tinfield lies between the Pioneer and the coast, and as water has been rather scarce the Tasmanian Government took over a 12-mile ditch and added 20 miles to it, costing $134,000 in all. The water now supplies 200 men, as the field is a "small man's" district. Water is supplied at a price varying according to the market price for tin. Payments are made weekly in advance, or, failing this, on a royalty basis.

Tin ore recovered during the last year was royalty scale, 14.9 tons, and fixed scale, 49.9 tons; a total of 64.8 tons black tin. Recently three pumping plants were put into commission for pumping water from the ditch to the Garfield ridge, a maximum height of 200 ft., but it is only the high price of tin that justifies the payment of a high price for the water, in addition to the cost of pumping.

Bolivia.[1]—There are detailed records of 115 tin mines, and there may be as many as 25 more tin prospects. These 115 tin mines may be divided into three classes, viz: 44 are good mines, some of which require more capital to operate; 27 are financially embarrassed and able to do but little development work on their tin veins; and 44 are prospects. Bolivia has nine departments, but in only four departments, namely, La Paz, Cochabamba, Oruro and Potosi are tin mines to be found.

Department of La Paz.—The Sociedad Anónima de las Minas Huaina-Potosi y Milluni has 653 hectares of mineral land (1 hectare = 10,000 square meters = 2.4711 acres) on which are about 20 veins of tin and bismuth with an average content of 5 per cent. tin. The monthly production amounts to 1000 Spanish quintals (1 Spanish quintal = 101.4 lb.) of concentrate containing 55 to 60 per cent. tin. The company employs 200 men at daily wages of Bs. 1.20 to 2 ($0.60 to $0.80). The company has a good concentrator, also houses for officers and miners. The property is 12 1/2 miles by good wagon road from La Paz.

The Mina Kala-uyu property consists of 450 hectares in the mountains of the Autajahua and Pacolla, Cercado province. The veins contain 10 per cent. tin, the ore being stannite. The production amounts to 800 quintals of concentrate per month of 60 per cent. tin. The company employs 20 men, who work by contract and receive Bs. 16 ($6.40) per quintal. The company has a good future, but will need $50,000 to open a tunnel and build a concentrator (at present the concentration is done by hand sorting by Bolivian women) and an aerial rope way to convey the ore from the mine. The property is 9 1/2 miles from the railway from La Paz to Guaqui.

The Empresa Providencia property consists of 300 hectares upon the mountains of Chilaya and Chunchumany. This property has 40 veins which average 10 per cent. in tin. The production varies between 150 and 200 Spanish quintals of concentrate of 68 to 72 per cent. tin; employs 30 men at daily wages of Bs. 1.20 to 2.50 ($0.48 to $1.00), and has a small concentrator, and houses for staff and workmen. The Empresa de Estaño en Araca has 502 1/4 hectares at Viloco. There are two large veins each 2 meters wide which carry from 12 to 19 per cent. of tin, and produce 2000 to 2500 quintals of 60 to 65 per cent. concentrate per month.

[1] Abstracted from G. W. Wepfer, *Min. Sci. Pr.*, Feb. 7, 1914.

This company employs 225 men. A branch railway to the Viacha-Oruro railway would greatly benefit this company and with additional capital the mines yield a much greater production.

The Monte Blanco property is in the valley of Guallatani of the Cordillera Quimza-Cruz at an altitude of 17,984 ft. The veins are as much as 2 meters wide and of an average tin content of 8 per cent. At the intersection of veins, the ore assays from 40 to 50 per cent. of tin and contains many fine large specimens of cassiterite. There are 20 veins of uniform size and grade in the property. This company is new and has not yet completed its equipment. The reserve of 13 per cent. tin ore in sight amounts to 200,000 tons.

The Concordia property was first known as the Andes Tin Co. The property comprises 477 hectares of mineral ground in the vicinity of Santa Vela Cruz. The ores contain from 3 to 19 per cent. tin and the production averages about 200 Spanish quintals from the veins and from old dumps, but it is expected to be greater as soon as the new installations are completed. The concentrator includes a stamp battery, Chilean mills, jigs, and Wilfley tables. The company has a hydro-electric power-plant and about 70 men at present occupied in road making.

Department of Cochabamba.—The Minas de Tucsuhuma is an Argentine enterprise which controls 64 hectares mineral ground upon the mountains of Tucsuhuma and Jatum-Kaka in the mountain range of Colcha. One vein is 1 meter wide containing 3 to 4 per cent. tin. The main tunnel "Escorial" is lined with hewn stone and affords access to all the interior workings. The production is 500 quintals of concentrate of 65 per cent. tin. The mine employs 140 men who receive Bs. 2 ($0.80) per day. There is a mill on the property, but for better work a wagon road is required from the mine to Colcha, connecting with the railway from Oruro to Cochabamba. The Santa Rosa Co. has 35 hectares upon the mountains of Huaillacocohi and Tucsuhuma in the Canton of Colcha. There are two veins, 3 meters wide, containing 8 per cent. tin. The property is in a state of development at present with a short tunnel 200 ft. long, and is expected to produce 500 quintals per month. The company would be benefited by a concentrator and a wagon road about 6 miles long from Tucsuhuma to Colcha.

The Berenguela Tin Mines, Ltd., owns 50 hectares in the Berenguela mountains in the Canton of Colcha. Within this area are two veins in tin, each 3 meters wide, carrying from 3 to 4 per cent. of tin. The actual production per month is 700 quintals of 64 per cent. tin concentrate. There are 73 men employed with a total monthly expense of Bs. 1200. The work is restricted on account of the scarcity of water for the mill.

Without this difficulty the company could easily produce 1000 quintals per month. .

Department of Oruro.—Empresa del Socavón de Oruro y Dependencias is also known under the old name Compañia Minera de Oruro. It belongs to the Bank of Chile in Santiago and comprises 252 hectares. There are 10 principal veins of an average content of 6 per cent. tin and some silver. The tin occurs as sulphides and oxides. The monthly production consists of 1121 metric tons averaging 10 marcos silver per cajon and 7 per cent. tin. The company employs 770 men at daily wages of Bs. 0.80 to 4 ($0.32 to $1.60). The various mines have commodious buildings for offices for the staff and men at Oruro and the mine. The property is 2 1/2 miles by wagon road from the city of Oruro. All the minerals are conveyed to the concentrator at Machamarca, which is 18 miles from Oruro by a branch railway. The sulphides are roasted and leached, and the tailings are concentrated. In the concentrator, 290 men are employed at wages between Bs. 1 and 4.50 ($0.40 to $1.80) per day.

The Compañia Minera de San Jose has 87 hectares of mineral lands northeast of Oruro at a distance of only 2 1/2 miles from that city. The yearly production amounts to 4500 Spanish quintals of 55 per cent. tin concentrate. The company employs 500 men at average daily wages of Bs. 2 ($0.80). The ores are sent to the Alantaña mill in the province of Poopo on the Antofagasta Oruro railway.

The Empresa Huanuni de Penny and Duncan operates 193 hectares upon Pozoconi mountain. There are two companies at work, namely, the English company, Harrison & Co., and the Empresa, Penny & Duncan. The ore averages 8 per cent. tin and the monthly production is 2583 Spanish quintals of 70 per cent. concentrate. The company employs 768 men at average wages of Bs. 60 ($24) per month. This company has a large concentrating plant, and in the town of Huanuni buildings for offices, the staff, and the men.

The Compañia Minera el Balcón is an English concern which operates 16 different important veins on Pozoconi mountain, Canton Huanuni, Cercado province. The ore averages 8 per cent. tin. The production is 3570 quintals per month of 65 per cent. concentrate. The company has 400 men who receive wages of Bs. 1.80 to 4.50 ($0.72 to $1.80) per day. This enterprise is one of the best in the department of Oruro and has the best of equipment. The first-class ore is hand sorted to a grade of 55 per cent. and sent to Europe. The low-grade is sent to the El Balcón mill where a 65 per cent. concentrate is produced. The transport of the ore from the Cataricagua mine is effected by an aerial ropeway with a capacity of 3550 quintals per hour, to El Blacòn mill. A

branch railway from Huanuni connects with the railway station Machamarca, which is of great service to this company and others in that locality.

The Compañia de Estaño de Anteguerra property comprises 227 hectares with two principal veins and many branch veins. The Esperanza group is on the Chunchu mountain and produces 500 quintals of 70 per cent. concentrate. The company employs 150 men who receive wages of Bs. 2.50 to 3.45 ($1 to $1.38) per day, and 12 men with a monthly salary of Bs. 200 ($80). The Empresa Avicaya is a company operating a property in the mountain Chullagrande in the province of Paria, 65 miles from Oruro with a 6-mile wagon road to the station of Pazna. The holdings of the company cover an area of 300 hectares and the ore assays as high as 40 per cent. but the average is about 17 per cent. tin. The monthly production is 3500 quintals of 70 per cent. concentrate. The mine shaft is 656 ft. deep. An aerial ropeway 8200 ft. long brings the ore from the mine to the mill. There are between 500 and 600 men employed. Near by are other companies with equally good prospects, but they are doing nothing on account of lack of funds.

The Empresa Magariños property consists of 110 hectares on Villacollo and Sillacollo mountains with an average of 20 per cent. of tin, and at the intersection of veins as high as 30 per cent. The production is comparatively small and irregular on account of lack of funds, but 500 quintals of 65 per cent. concentrate per month could easily be produced.

Department of Potosi.—The Empresa Soux Hernández, on Mount Potosi, has 10 tunnel mines employing 945 men who receive Bs. 1 to 2 ($0.40 to $0.80) per day. In 1909 this company produced 385,350 quintals. Other properties of the company which were worked by 187 men produced 7700 quintals with contents of 30 to 40 per cent. tin. The company has the large modern mill Velarde and an aerial tramway to transport the ore from the mine to mill. Besides this mill the company operates the Huaillahuasi, Quintanilla, and Pampa mills which employ 1187 men, who receive an average of Bs. 1.50 ($0.60) per day.

The Bebin Hermanos are operating five mines with 570 men, who receive Bs. 1.50 to 1.60 ($0.40 to $0.64) per day. The mines produce silver and also about 2500 quintals of 50 per cent. tin concentrate per month. The company has 10 other properties which are not being worked and the modern concentrating mills Huayra and Santa Rosa.

The house of Metting is working six mines and has five others in reserve. The production is 586 quintals per month of between 45 and 55 per cent. tin. There are the two mills, the Candelaria and Alanta employing 70 men who receive Bs. 1.40 ($0.56) per day. These mines of Eduardo la Iglesia have a good future; they comprise seven properties,

but only two, the Milagro and La Patria are being worked. In the Milagro 58 men are employed at wages of Bs. 0.80 to 1.60 ($0.32 to $0.64). The production amounts to 200 quintals per month. La Patria with 80 men and the same wages produces 400 quintals. The Patria has the Laguacayo mill and the Milagro mine has the Milagro concentrating plant.

The Cosme Alurralde Co. is one of the best mining companies on Mount Potosi and has 11 mines, but work is carried on for the present only at the Rosario property. The production amounts to 417 quintals of 50 per cent. tin concentrate per month and some silver. The company employs 340 men, who receive Bs. 1 to 2 ($0.40 to $0.80) per day. At present the ore is hand sorted.

Vladislavichy y Cia. have two mines and three mills which produce 642 Spanish quintals of 50 to 55 per cent. concentrate per month with 95 men. This company has a good future. Tomas Elio has four mines and the Escalante mill which produces 400 quintals of 57 per cent. tin concentrate per month. Primitivo Calvimonte has two mines and the Golpeadero and San José mills. He is working 134 men and produces about 420 quintals of 60 per cent. tin concentrate. Matias de Mendieta has the two mills Chaca and Esperanza at Rivera and with 93 men is producing 1000 quintals of 55 per cent. concentrate per month. Roman Lopez owns the Victoria and San Felipe mines and employs 120 men. The property produces 420 quintals of 50 per cent. concentrate.

La Salvadora, which belongs to Sr. Simón I. Patiño, has 4 hectares on the Juan del Valle mountain in the canton of Uncia and a mill which is considered the best and most complete in Bolivia; the work throughout is conducted upon best practice by careful and efficient engineers. The content of the ore fluctuates from 1 to 75 per cent. tin. The mine has a depth of more than 960 ft., all of which is being exploited, using electric rock drills with good results. The ore is raised by electric hoists, the electric power being produced at the Mira-Flores mill. The ore is conveyed from the mine by an aerial tramway 12,344 ft. long to the mill and can deliver 1500 to 2000 quintals in 12 hours. The production is 17,000 quintals of 65 per cent. concentrate, and 3000 quintals of ore which needs no concentration, as it assays 57 per cent. tin.

The Compañia de Unica has been acquired by Sr. Simón I. Patiño for the sum of £150,000 cash. This was an Irish company conducted by the well-known engineer, Sr. Juan B. Minchin, situated in the Chayaguena mountains of Uncia and consists of the following groups; Carmen with 12 hectares, Industria with 15 hectares, San Antonio with 12 hectares, Pizarro with 7 hectares and San José with 12 hectares. Sr. Simón I. Patiño has now two large mines, namely, "La Salvadora" and the "Compañia de

Unica" and will [illegible] produce 25,000 quintals per month of 62 per cent. concentrate, by means of the Victoria mill of La Salvadora.

The Compañia Estañifera de Llallagua is owned by Santiago interests; it has 212 1/2 hectares in Llalluagua mountains with two large veins, La Blanca and the San Fermin. The production is 600 quintals per month, with 600 men. The wages are Bs. 3 ($1.20) per day.

EXPORTATION OF TIN ORE FROM BOLIVIA.
(In metric tons.)

Year.	*Barrilla.* Tons.	Tin Contents. (a)	Year.	*Barrilla.* Tons.	Tin Contents. (a)	Year.	*Barrilla.* Tons.	Tin Contents. (a)
1901..	21,573	12,943	1907.	27,678	16,607	1913...	.....	.....
1902..	17,340	10,404	1908.	29,938	17,963	.....	.....	.....
1903..	21,785	13,071	1909.	35,566	21,340	.....	.....	.....
1904..	20,369	12,221	1910.	38,548	23,129	.....	.....	.....
1905..	27,690	16,614	1911.	37,073	22,244	.....	.....	.....
1906..	29,370	17,624	1912.	38,379	23,027	.....	.....	.....

(a) Tin content of the barrilla (black tin concentrate), computing the latter at 60 per cent. metallic tin.

RECEIPTS OF BOLIVIAN TIN AT LIVERPOOL, HAVRE, AND HAMBURG. (a)
(In tons of 2240 lb.)

Year.	Liverpool.				Havre. Tons Fine.	Hamburg. Tons. Fine.
	Bars.	Ore.		Total Tin.		
		Crude Weight.	Metallic Content.			
1903	1,614	10,401	6,240	7,854	.....	.....
1904	1,573	13,824	8,294	9,867	.....	.....
1905	1,386	17,504	10,504	11,888	.....	.....
1906	1,569	20,489	12,293	13,862	691	1,827
1907	1,143	18,532	11,119	12,262	924	2,390
1908	1,174	21,502	12,901	14,075	863	2,056
1909	834	22,859	13,716	14,550	1,216	2,275
1910	1,003	24,524	14,724	15,727	808	1,690
1911	464	29,676	17,805	18,269	1,155	3,170
1912	552	20,694	12,416	12,968	645	7,655
1913	.....	.....	.....	.....	.....	.....

(a) As reported by H. A. Watson & Co., Liverpool.

The Aramayo Francke y Cia., Ltd., property is one of the largest enterprises in Bolivia, with headquarters at Quechisla, North Chichas. The company has 3524 hectares containing veins of tin, bismuth, wolfram, and silver in the districts of Chorolque, Chocaya, and Tasna. The average assay of tin ore is 18 per cent. and there are pockets of cassiterite assaying as high as 70 per cent. of tin. The rich material is hand sorted for shipment to Europe. The Santa Barbara, Sala-Sala, and Cotani mills treat the Chorolgue ore. For this district, the company employs between 600 and 800 men and produces about 5000 quintals of 60 to 65 per cent. tin. The ore from the mines at Tasna, containing tin, bismuth, and

wolfram, are treated in the Buen Retiro mill. The Chocaya property has the Asllani mill at an altitude of 13,123 ft. The property is equipped with an aerial ropeway 9842 ft. long to transport the ore from the mines to the mill. There are 600 men employed at this property, producing 6373 quintals per month of 55 to 60 per cent. concentrate. The yearly production of this company is about 71,700 quintals of tin concentrate. The wages vary between Bs. 1.20 and 5 ($0.48 and $2) per day. At Quechisla, the company has a new installation for the smelting of ores of bismuth and copper, an electric power and light service, and good buildings for the staff and the men.

China.—As a tin producer, China is surpassed only by the Straits Settlements and Bolivia. Nearly all the supply is brought from Yunnan to Hongkong, where it is refined and shipped to Europe and America or distributed to the Chinese market. The output of Yunnan is now hampered by limited water-supply, difficulty of transport, and the high cost of fuel and food.

German interests have constructed a tin-refining plant at Ko-Chiu to turn out 50 tons of standard tin per day by coal-gas furnaces. It has never been fully worked, as all the coal has to be transported from Pi-Chi-Chai by mules, but as soon as the branch line is built, coal will be plentiful, and if water can be had the output will probably exceed 50 tons per day, as at present without a refinery the output is over 30 tons per day from the native smelters, which turn out tin averaging 84 per cent. pure, to be shipped to Hongkong for refining in native furnaces. Tin is found from the east side of the range, about 8 miles from Meng-tze, to the western bank of the Red river, an area 24 miles wide by about 56 miles long.

New tin mines in south China are to be developed in the new British territory, the Kowloon extension, according to Vice-Consul General A. E. Carleton, of Hongkong. Some 40 shafts have been sunk, and tin has been obtained from every one of them in quantities, it is claimed, that leaves no doubt of the remunerative nature of the enterprise, in fact a Straits company is prepared to take any quantity of the unsmelted ore at about $735 per ton. It is proposed to operate the tin-bearing soil by dredges.

Exports of tin from Hongkong[1] underwent notable developments in 1913, the United States being the chief factor in the change. The total amount of tin exported during the year fell off materially from the exports of 1912, which were in fact abnormally large as a result of the sudden development of mining plants in Yunnan Province on a modern scale, as well as the sudden release of stocks held in the in-

[1] *Daily Consular and Trade Reports.*

terior by interference with transportation. Whereas formerly tin was purchased in the Far East and shipped to Europe and thence to the United States, now larger portions of the exports are proceeding direct. Exports of tin from Hongkong to the United States in 1913 amounted in declared value to $1,632,213, as compared with a declared value of $1,404,115 in 1912 and $798,941 in 1911, the exports previous to that time being too small to merit separate enumeration in the returns. This increase in shipments to the United States has been directly at the expense of Europe. Returns of the Hongkong General Chamber of Commerce show that the exports of tin from Hongkong, in slabs of 112 lb., during the past 2 years have been as follows:

Destination.	1912.	1913.
	Slabs.	Slabs.
United States	27,551	36,793
Great Britain	24,752	8,047
Continental Europe	63,772	32,575
Total	116,075	77,413

The movement of tin to the United States occurred chiefly in the first two quarters of the year, the declared value for the March quarter having been $764,092 and that for the June quarter $511,135, the half year constituting more than three-fourths of the whole. The year's trade opened briskly with comparatively high prices and with a decided advantage in favor of Chinese tin as compared with tin from the Straits Settlements and from other parts of the world. A fall in prices in the summer, however, temporarily stopped the movement. At the beginning of 1914 shipments were renewed at a largely increased rate.

The output of the metal from the Yunnan mines during the year is placed by the trade at about 14,000 tons, as compared with about 10,000 tons in 1912, but owing to various disturbances and disorder the total output anticipated by the trade was probably not reached. There was some accumulation of stocks in Hongkong during the latter part of the year, the close of the season finding about 13,500 piculs of 133 1/3 lb., valued at about $750,000, on hand.

Dutch East Indies.—A few years ago it was decided to undertake mechanical working for tin in the Boeboes valley, district of Blinjoe, Residency of Banka, by an electrically driven sluicing suction installation. The construction of the power station near Mantoeng (Klabat Bay) has been delayed, but its completion may soon be expected.

The centralization of motive power for the tin workings will be pushed forward, because the procuring of wood fuel for the large number of scat-

tered steam installations is gradually becoming more difficult and costly. For instance, in the districts of Merawang and Pangkalpinang almost all the available wood in proximity to the workings is exhausted. Moreover, only certain kinds of wood are suitable for charcoal; in most cases such wood as is not suitable for timber is also unsuitable for charcoal. As to the quantity of wood necessary for the smelting works at Banka, during the last few years about 200,000 cubic meters of wood have been used per year. Furthermore, the large number of workmen required to obtain the wood could be much better employed at the workings themselves. This difficulty will be felt even more severely in the future if the importation of coolies, which has been fairly satisfactory during the last few years, becomes again more troublesome. It has therefore been decided to construct a large power station for the districts of Soengeiliat, Merawang, Pangkalpinang, and Soengeislan, the cost of which will amount to more than £125,000.

During 1913 there were sold at public tender in Batavia 66,000 slabs (74.8 lb.) of Billiton tin, totaling 4,938,800 lb., at an average of $0.4261 per pound. At the tenth sale for the year, on Oct. 8, the 5500 slabs averaged $0.388; at the eleventh sale, on Nov. 5, the 5500 slabs averaged $0.3847; and at the twelfth sale, Dec. 3, the 5500 slabs averaged $0.3698 per pound. In the earlier months of the year, the average prices were: Jan. 8, 5500 slabs at $0.4806; Feb. 5, 6000 slabs, at $0.4697; March 5, 5500 slabs, at $0.45422 per pound.

Federated Malay States.—Exports of tin and tin in ore (the metal contents of the latter being estimated at 70 per cent. for purposes of taxation) amounted to 828,176 piculs (50,101 metric tons) in 1913, an increase of 886 metric tons, or less than 2 per cent. over 1912. The increase was undoubtedly due to the expansion in dredging operations which are now being conducted in many places on a large scale and by modern methods.

PRODUCTION OF TIN IN THE FEDERATED MALAY STATES. (a)

(In Piculs of 133⅓ lb.)

	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Perak.....	446,781	435,909	431,386	467,784	461,665	421,335	437,339	.....	.....
Selangor.....	289,867	268,624	273,900	282,540	266,007	240,192	231,175	.....	.....
Negri Sembilan	85,133	77,766	75,155	64,221	48,072	34,697	29,230	.....	.....
Pahang.....	34,879	34,488	33,195	39,520	43,144	40,674	43,954	.....	.....
Total.....	856,660	816,787	813,636	854,065	818,888	736,898	741,698	813,472	828,176
Metric tons ...	51,793	49,859	48,411	51,654	49,529	44,579	44,870	49,215	50,101

(a) Exports of tin ore, the latter being calculated to its assumed metal contents, upon which duty is paid to the F. M. S. government.

Three London companies are now operating tin dredges: Malayan Tin Dredging Co., the Kamunting Co., and Ipoh Tin Dredging, Ltd. Two Australian concerns are similarly engaged: Tongkah Harbor Tin Dredging, and Tongkah Compound; while two more, the Austral-Malay Tin Syndicate, another Malay Peninsula Syndicate, are about to begin dredging operations.

IMPORTS OF TIN AND TIN ORE INTO GERMANY.
(In metric tons.)

Country.	Tin Ore.				Country.	Tin Metal.			
	1910.	1911.	1912.	1913.		1910.	1911.	1912.	1913.
Bolivia	15,925	15,227	13,296	.....	Dutch Indies	8,135	8,210	7,254	.....
Chile	914	1,874	2,133	.....	Australia	1,129	1,161	1,519	.....
Spain	227	.....	.....	.....	Straits Settlement	471	249	494	.....
Austria-Hungary	48	.....	.....	.....	Great Britain	1,302	1,524	1,644	.....
Great Britain	34	320	102	.....	British Indies	1,105	1,266	1,387	.....
Other countries	195	550	1,026	.....	Other countries	2,155	2,140	3,252	.....
Total	17,343	17,971	16,557	.....	Total	14,297	14,500	15,550	14,428
Value (1000 M.)	26,709	35,921	33,114	.....	Value (1000 M.)	43,773	55,282	59,244	.....

Mexico.[1]—Cassiterite is widely distributed in Mexico, and has been exploited in the States of Durango, Jalisco, Guanajuato, and San Luis Potosi. Some of these occurrences have previously been described in the *Trans. Am. Soc. Min. Engrs.*, by Edward Halse, 1899, and W. R. Ingalls, 1895. It is only within the last 2 years that foreigners have acquired extensive interests in the tin deposits. The following notes relate to the mining and smelting operations conducted in the vicinity of San Luis Potosi.

The elevation of the tin regions is between 5000 and 9000 ft.; the prevailing rocks are acid porphyries (commonly rhyolite) intruding shale and limestone, and much decomposed by infiltration of metal-bearing solution.

Up to the present no systematic mining or prospecting has been done, and only in a few cases have the natives procured titles to the properties. They operate in the following manner: There is a small roving population of tin miners; sometimes ten or more of these will go to the owner of a ranch on whose land tin is known to exist, and arrange to pay him a small royalty on any ore extracted, besides a small rent for the right to build their huts, use of firewood, and for wood to make the necessary charcoal for smelting their ore. This practice is of course illegal, because the tin does not belong to the owner of the surface but to the Mexican Government, and in this manner the Government is deprived of annual taxes for the mining claim, also the royalty on the metal extracted. When a promising outcrop has been "located," work is started at once and this is

[1] Geo. C. Master, *Min. Mag.*, reprinted in *Mex. Min. Jour.*, Nov., 1913.

often profitable from the commencement. In most cases the first few feet of excavation can be accomplished without the use of explosives, pointed bars and wedges being used; in fact, the actual veinstuff is always mined with such tools, powder being employed only in sparing quantities to loosen the surrounding country-rock where it is exceptionally hard. The workings themselves are usually irregular, having followed the shoots only where it paid to work them, but in one or two cases veins can be traced on the surface by old workings for over 500 ft., some of which have fairly regular open stopes, from wall to wall measuring about 3 ft., and in some cases these workings are more than 100 ft. deep. In places there are good-sized stopes where the ore-shoots have widened out to 6 and 10 ft. All ore and waste is carried out in sacks on the backs of the miners, and it is a rare occurrence to find them using a windlass, but this is partly explained by the irregularity of the workings and the want of sufficient capital to sink proper shafts.

The ore is cobbed to about 1/4 in. by hand, and sorted; then washed. The concentrate varies in richness, but it averages from 45 to 65 per cent. tin. The concentrate is then dried, collected in sacks, and put aside for smelting.

The small blast-furnaces used by the natives are built of any hard stone, cemented together by a clay, *tierra del fuego*, found locally in most of the districts. The furnace is 2 ft. 6 in. high; at top the feed opening measures 5 in. square; the front inside is vertical but the back and sides slope outward, and the inside diameter at the bottom is 9 in.; the bottom of the furnace has a steep slope toward the open hearth in front, the latter being merely an excavation with a clay-lined floor. In some cases *adobes* are built up 2 or 3 ft. high on top of the furnace to protect the men at the bellows from fumes and sparks. The blast is produced from two ox-hide bellows, worked alternately by two men. The nozzles of these two bellows unite, forming one tuyère, made of a piece of iron pipe, about 8 in. above the bottom of the furnace; the blast enters the latter through a hole of 3 in. diameter. Much air is lost at this point, but the reason for having the hole so large is that the furnaceman can use it for looking into his furnace and can insert a small iron bar should the charge cake, without having to stop the blast entirely. When the concentrate is low in tin contents, for instance 45 per cent. tin, it is customary to mix it with other concentrates of about 65 per cent., if the latter can be obtained in the district, in the proportion of two of the former to one of the latter. The concentrate obtained from washing the alluvial in the *arroyos* is always in great demand for smelting, because it is easier to flux and richer in tin, but its supply is very limited, on account of the precipitous sides of the *arroyos* and the general topographical features of the country, which

are not favorable to the collection of large alluvial deposits, at least in the immediate neighborhood of the veins. Individual miners sometimes strike rich pot-holes in the river-beds, and these are worked from year to year, because during every rainy season they collect considerable tin oxide; this, when washed and concentrated, will assay 70 per cent. tin.

Before commencing operations the furnace and hearth are always re-lined with clay, and when dry, charcoal is fed into the furnace and a light blast admitted until the temperature begins to rise; then moistened concentrate (which has previously been crushed to 1/8 in.) is fed, in the proportion of one part of concentrate to three parts of charcoal (by weight); when the furnace is thoroughly hot, one part of "hard-head" is fed to eight parts of concentrate. Hard-head is tin and iron alloyed in various proportions, and is obtained from the slag of previous smelting operations. As much as 450 lb. of various concentrates are often smelted at a time, and when the operation is nearing its end, the slag is broken to 1 in. and re-smelted. The second slag is broken afterward to 1/8 in. and carefully washed, the resulting pellets of tin and hard-head being reserved for a subsequent smelting operation. The treatment of 450 lb. of concentrates takes 16 hours. It is hard to give an exact estimate of the loss of tin in the operation because, as before mentioned, the washed slag and hard-head from previous smelting are always added, if available, and these vary considerably in their tin contents, but the probable loss is approximately 10 per cent.

The cost for smelting 450 lb. of concentrates is 16.08 pesos ($8.04) divided as follows:

	Pesos.
1350 lb. charcoal	8.64
One furnace-man at 12 cents per 25 lb. concentrate smelted	2.16
Four men at the bellows at 6 cents per 25 lb. concentrate smelted	4.32
One furnace-feeder at 6 cents per 25 lb. concentrate smelted	1.08
	16.08

The metal is allowed to run out on to the hearth every few minutes by lifting the solidified slag and clinkers with a long pole tipped with iron. This method is wasteful and a large percentage of the tin adheres to the clinkers. When about 25 lb. tin has been run out, it is doubled up and eventually shipped in sacks, each containing 100 lb. There is always a good market for the tin locally; the store-keepers in the nearest towns buy the metal to re-sell at a profit to the large firms in Mexico City. The tin is thus sold without being refined and contains from 90 to 96 per cent. metal.

Nova Scotia.—It is reported that a tract of nearly 4000 acres has been taken up by prospectors in Lunenburg County, near Lake Harris, which is about 20 miles from Chester Basin, the nearest railway station, 40 miles southwest from Halifax. Such reports as have been received indicate

that a series of narrow veins cross the entire property, the largest being probably about 4 ft. thick, the country rock being granite and slates. In this vincity there are one or more eruptive porphyry dikes, and the quartz veins follow fissures due to the intrusion of the porphyry, wolframite being found principally in the quartz, and the tin in altered, very feldspathic granite. The tin, while largely cassiterite, is also to some extent in the form of stannite, the latter being associated with some copper and iron pyrites. The tungsten occurs as wolframite. Scheelite has been found and mined in Halifax County.

The property has just begun to be prospected by trenching through the heavy vegetable growth, and by two shafts which have reached a depth of something under 30 ft. It is said that the mineralization of these narrow veins is quite uniform; a large number of samples taken from widely separated points running from about 2 per cent. of metallic tin, as a minimum, to about 2.75 per cent. as a maximum. The average of tungsten has not been determined. Judging from specimens which we have seen, the coarse mica which usually characterizes the tin occurrence in the so-called greisen or pegmatite veins is absent, and this would be an advantage in concentration, as it has been found in practice that in spite of the great difference in specific gravity, mica carries off mechanically a considerable portion of fine cassiterite.

Russia.[1]—Tin deposits in Russia are known only in the Transbaikal Province, Siberia, and in Pitkaransk, Finland. The latter are not worth attention. The Transbaikal deposits are more interesting, although hitherto unexploited except to a small extent in the first half of the nineteenth century by the Government itself. All the Russian requirements in tin are supplied by England, Holland, Germany and France. Till 1890 Russia imported about 1620 tons yearly average, increasing to 4540 tons in 1908, 4660 tons in 1911, and 4800 tons in 1912. Tin pays duty on entering Russia as follows: ingots, rods, and scrap, 4s. 5 1/2 d. per hundred weight sheets, 6s. 7d. per hundred weight. The occurrences of tin in Transbaikal are, in respect to geological formation, very uniform, the principal rocks being granite and schist, mostly decomposed. The occurrence of cassiterite for about 60 miles along the river Onon justifies the conclusion that here we have a genuine tin district. At present, in the Transbaikal Province cassiterite is known to exist in the following places on the river Onon or its tributaries: (1) Near the village of Oloviany Rudnik, on the left bank of the Onon; (2) in the valley of the river Malaya Kulinda, tributary of the Onon; (3) near the village of Nishni Sharanai, on the right bank of the Onon, and (4) near the village of Zavitinsky, on the right side of the river Ingoda.

[1] E. de Hautpick, *Min. Jour.*, May 10, 1913.

The best known of these deposits is the first named, that near the village of Oloviany Rudnik. It lies 145 miles from Nerchinsk, and about half a mile from the station of Olovianoy, on the Transbaikal Railway. The outcropping rock here is clayey schist overlying granite, intersected by quite large lodes of milk-white quartz. The general direction of the lodes is uniform, notwithstanding several flexures and deflections. Their thickness is 0.7 to 0.15 meters. The walls of the lodes consist chiefly of mica. Cassiterite is found both in the walls and in incrustations in the quartz itself. The tin content is 2.5 to 5 per cent. These mines have been known since 1812, and up to 1853 they were slightly exploited. The exploitation of Transbaikal tin deposits is coming to the front again, and some of these mines are to be tested by a German company.

Siam.—A British consular report mentions that extensive applications have been made to the Siamese Department of Mines for concessions to work tin deposits in the Island of Koh Pa Ngan, near Koh Samui in the Bight of Bandon, off the coast of the Malay Peninsula. Six square miles have been applied for in three equal blocks by Siamese, Australian, and Chinese syndicates. It appears likely that the concessions will be taken over by the Tongkah Harbor Dredging Co., an Australian concern.

The report of the above-mentioned company for the year 1913 states that 3,336,190 cu. yd. of gravel yielded 1339 long tons of tin-ore concentrate, an average of 0.9 lb., worth 23 cents per cubic yard. Working costs were 7.6 cents per cubic yard; and other expenses, incurred mainly in performing the dead work of dredging the harbor, as stipulated in the concession, averaged 1.4 cents per cubic yard. The total receipts from the output was $758,000, making profits of $385,000. The company's sixth dredge, having a digging reach of 60 ft., has just been finished in Scotland, at a cost of $124,800.

United Kingdom.[1]—The gradual lowering of tin prices, which at the end of 1913 brought the price down some £60 per ton since the beginning of the year, had the effect of reducing the income of the 15 leading companies by approximately £63,240, or over 9 per cent. of the total gross receipts for tin, while the amount of ore sold was less by 162 tons.

During the year Killifrith mine was started by E. S. King & Co. The adit was cleared and the installation of the pumping and winding plants accomplished. At Tresavean a mill is under erection. The Mulberry mine, being worked as the Hillside Syndicate, is now producing and selling the product privately. The Silver Valley mine at Liskeard has been closed down. The Prince of Wales mine has been unwatered to below the 166-fathom level. Crushing operations are in full swing in the old battery, which has been repaired; about 10 tons of tin ore concentrates

[1] *Min. Jour.*, Jan. 3, 1914.

are produced per month. Operations at South Great-work, and Leeds and Lemon are being pushed forward in the Lady Gwendolin set, a battery being erected to treat the ore above the adit. At North Dolcoath a shaft has been timbered to the 100 ft., and preparations are now being made to start pumping. Falmouth Consolidated, after being worked for some time on debenture money, has ceased producing.

The Cornish Tin Smelting Works was sold to Messrs. Vivian, Younger & Bond as a going concern, and this firm has secured 33 per cent. of the tin sold at the ticketings. At the Basset & Grylls, development is being pushed forward, a crosscut from the 60-fathom north has been driven 200 ft., and cut the Wheal Cock lode, which is now being driven on. Dredging for tin, both in St. Ives Bay and Falmouth river, have not as yet received official sanction. Diamond drilling at South Crofty has proved a failure, the rate of progress not being sufficient, and the diamond losses very high.

Phoenix mines are steadily progressing, Messrs. Bewick, Moreing & Co. having secured another £15,000 for development work. The Great Dowgas mine has been closed down, and sale of the plant piecemeal has taken place. Carn Brea has partially closed, having suffered during the last 9 months from a falling off in the grade of the ore and the low price for tin. There is a likelihood that fresh capital will be raised. At North Tincroft the ore-body is 5 ft. wide, showing profitable values. The Highburrow East has given high-grade ore in the past, and there are strong evidences of still more to follow.

IMPORTS OF TIN ORE INTO GREAT BRITAIN.

	1911.		1912.		1913.	
	Long Tons.	£	Long Tons.	£	Long Tons.	£
South America.....	21,439	1,738,059	21,085	1,869,847	24,806	2,465,235
British South Africa..	3,407	342,031	826	99,235	880	117,944
Other countries.....	3,991	226,106	6,741	431,804	9,906	725,784
Total.....	28,837	2,306,196	28,652	2,400,886	35,592	3,308,963

IMPORTS OF METALLIC TIN INTO GREAT BRITAIN.

	1911.		1912.		1913.	
	Long Tons.	£	Long Tons.	£	Long Tons.	£
Straits Settlements, Malay States and Labuan.	39,691	7,566,633	36,069	7,501,484	.....	.....
Australia.....	3,571	679,960	3,244	677,066	.....	.....
Other countries.....	2,644	492,879	3,844	791,594	.....	.....
Total.....	45,906	8,739,472	43,157	8,970,144	47,217	.....

TIN SUPPLY OF GREAT BRITAIN.
(In long tons.)

	1910.	1911.	1912.	1913.
From domestic ores (*a*)	4,797	4,872	.....	.....
From imported ores(*b*)	12,850	13,632	13,386	.....
Imported metal	46,285	45,906	43,157	.....
Total supplies	63,932	64,410	.....	.....
Exports (*c*)	31,539	34,025	32,733	.....
Consumption(*d*)	32,393	30,385	.....	.....

(*a*) Amount of tin "obtainable" by smelting; the exact recovery is not stated. (*b*) Estimated by the *Metallgesellschaft*. (*c*) Of foreign origin only. (*d*) Disregarding fluctuations in stocks. (*e*) Partly estimated.

According to the ticketing papers, the output of Cornwall and Devon in 1913 was 5773 long tons of concentrate, of a total value of £692,821, or £120 per ton, compared with 5935 tons, worth £752,771, or £127 per ton in 1912. The reduction in average selling price during 1913 was equivalent to a loss of £63,240 income by the 15 leading producers.

Imports of tin ores into the United Kingdom in 1913 totalled 34,592 long tons (£3,308,963), compared with 28,651 tons (£2,400,841) in 1912. The most noteworthy increases in 1913 were 3388 tons from Northern Nigeria against 1631 tons in 1912, and 20,663 tons from Bolivia, against 14,906 tons in the previous year.

The Tin Market in 1913.[1]—The year 1913 opened with prices at the high-water mark, almost 51 cents being paid for spot and nearby material. It remained at this level up to the beginning of February, the unstableness of the market, however, being evidenced by a considerable discount for future tin. The market declined at the beginning of February to about 48 3/4 cents, which, in comparison to former figures, was considered as low and attracted buyers, so that a good-sized business was placed in London from this side, with the result that prices advanced again about 1 cent per pound.

The bears on the London Metal Exchange became active the latter part of February, attacking the market by selling considerable quantities of future tin and thereby creating a backwardation for this class of about £7 against spot, while this market varied from 48 to 48 1/2 cents.

The market developed further weakness in both spot and future tin during March, when the precarious financial conditions on the Continent led to liquidation. London prices declined about the middle of March to £210 for spot and £206 1/2 for three months, and metal in this market was offered at 1/4 to 3/8 cents per pound under the parity of these prices, namely, 46 cents.

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

When statistics for March disclosed heavy American deliveries, buying both here and in London became active and prices advanced quickly about £9 in London and 2 cents here. It retained this strong tone all during April. The rise culminated at the end of that month, when London quoted £230 for spot and £220 1/4 for three months, while domestic sales were made at around 50 cents.

Again the April statistics proved to be favorable, as shipments from the Far East had fallen off considerably and a scarcity of spot tin developed, which advanced this class £12 over three months in London. American consumers were more fortunate, in that an accumulation of tin existed on this side and offers therefrom were freely made at almost 1 cent per pound below the London parity. At that time, prices stood at £231 for spot and £223 1/2 for three months in London, and 50 1/2 cents in this market. From this level prices declined quickly, through a reported falling-off in consumption in this country and renewed speculation of one of the largest operators.

Statistics for May, as far as the United States was concerned, deteriorated considerably and were also a very important contributing cause for the decline of the metal. During the second half of June prices were at about £202 for spot and £202 3/4 for three months in London, and around 45 cents in New York.

The aggressiveness of the bear element in the London market did not leave the market very long at this level, and their heavy sales broke prices during the first 10 days of July to £177 1/4 for spot and £178 1/4 for three months in London, and 39 cents here. The market then steadied a little, as it was found that the Far Eastern interests were not willing to follow this decline and refrained from sales. This action developed a somewhat stronger tone in the London market and advanced prices about £12 from the previous low point.

AVERAGE MONTHLY PRICE OF TIN IN LONDON. (a)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.
	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d
1901	120 .9.10	122 .6.11	116.15 .6	116 .3 .0	123.13 .0	129.16.11
1902	105. 6 .5	114 .4 .9	115.10 .6	125.14 .2	134.13.10	129.12.10
1903	127.12 .6	133 .8 .1	137 .0 .6	136.19 .2	133.12 .0	127.11 .0
1904	130.10 .4	125.13 .6	126 .9 .8	127 .5 .1	125 .7 .2	119.11 .1
1905	131 .5.11	131 .3 .6	134.17 .2	140.11 .8	136.11 .8	138 .3 .6
1906	164.11.10	166 .0.10	166 .1 .2	176.14 .5	192 .6 .4	178 .0 .7
1907	190 .4 .0	191.18 .9	188.17 .6	187 .1 .2	191 .1.10	187.10.11
1908	128 .9 .0	128.14 .1	137.19 .8	143.12.10	135.11 .6	127.12 .2
1909	127 .7 .3	127.15 .3	130 .6 .7	133 .8 .3	131.16.10	133 .4 .0
1910	148 .3 .6	149.13 .0	147 .4.11	149.19 .3	150 .1 .8	148.13 .1
1911	187.17.11	189.12.10	182.12 .4	193 .0.10	197.15 .4	207 .7 .9
1912	191.14 .0	195 .4.10	192.15 .0	200 .8 .3	209 .6 .1	205.18 .9
1913	238 .5 .6	220 .2.10	213.12 .4	224 .3 .2	224.2 .10	207 .4 .2

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d
1901.....	127.19 .9	116 .1 .7	114.10 .6	113 .1 .5	114 .0 .7	108.17.10	118.12 .8
1902.....	127 .3 .2	126.10 .0	121.10 .7	117.11 .3	115 .2 .3	115.13 .5	120.14 .5
1903.....	125 .1 .7	127.16.10	120 .9 .6	115.17 .1	116.13 .9	125.15 .0	127 .6 .5
1904.....	119.18 .6	122 .5 .9	126 .7 .7	130.11 .6	133 .0 .5	133.15 .6	126.14 .8
1905.....	144 .6 .8	150 .5 .6	146.11 .9	148 .3 .6	152 .5 .3	162.14 .3	143 .1 .8
1906.....	170.12 .5	180.19.11	184.15 .3	195.15.11	195.15.10	195.19 .9	180.12.11
1907.....	188 .0 .2	170 .5 .9	166 .6 .6	146 .7 .7	138 .8 .8	125.10 .4	172.12 .9
1908.....	131 .6.10	134.16 .2	131 .6 .8	133 .8 .8	137 .8 .3	132 .4 .7	133 .2 .6
1909.....	131.19 .1	135.18 .3	137.14 .6	138.13 .2	140 .0 .3	149 .2 .3	134.15 .6
1910.....	149 .2 .1	155 .8 .2	160 .8 .7	164 .4 .9	166.18 .0	173.17 .3	155 .6 .2
1911.....	193 .2 .0	190 .9 .7	180.16.11	187 .2 .9	194.19 .4	203 .7 .2	192 .7 .4
1912.....	202 .8 .3	208 .3 .0	223.19 .6	228 .9 .1	227.16.10	226.17 .8	209 .8 .5
1913.....	183.10 .3	188.14 .7	193 .1 .6	184.16 .9	180.17 .5	171.15 .9	206 .5 .7

(a) As reported by Metallgesellschaft, Frankfurt-am-Main.

AVERAGE MONTHLY PRICES OF TIN PER POUND IN NEW YORK. (a)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899	22.48	24.20	23.82	24.98	25.76	25.85	29.63	31.53	32.74	31.99	28.51	25.88	25.12
1900	27.07	30.58	32.90	30.90	29.37	30.50	33.10	31.28	29.42	28.54	28.25	26.94	29.90
1901	26.51	26.68	26.03	25.93	27.12	28.60	27.85	26.78	25.31	26.62	26.67	24.36	26.74
1902	23.54	24.07	26.32	27.77	29.85	29.36	28.38	28.23	26.60	26.07	25.68	25.68	26.79
1903	28.23	29.43	30.15	29.81	29.51	28.34	27.68	28.29	26.77	25.92	25.42	27.41	28.09
1904	28.85	28.09	28.32	28.13	27.72	26.32	26.57	27.01	27.78	28.60	29.18	29.292	27.96
1905	29.325	29.262	29.523	30.525	30.049	30.329	31.760	32.866	32.095	32.481	33.443	35.835	31.358
1906	36.390	36.403	36.662	38.900	43.313	39.260	37.275	40.606	40.516	42.852	42.906	42.750	39.819
1907	41.548	42.102	41.313	40.938	43.149	42.120	41.091	37.667	36.689	32.620	30.833	27.925	38.196
1908	27.380	28.978	30.577	31.702	30.015	28.024	29.207	29.942	28.815	29.444	30.348	29.144	29.455
1909	28.060	28.290	28.727	29.445	29.225	29.322	29.125	29.966	30.293	30.475	30.859	32.913	29.725
1910	32.700	32.920	32.403	32.976	33.125	32.769	32.695	33.972	34.982	36.190	36.547	38.199	34.123
1911	41.225	41.614	40.157	42.185	43.115	44.606	42.400	43.319	39.755	41.185	43.125	44.655	42.281
1912	42.529	42.962	42.577	43.923	46.053	45.815	44.519	45.857	49.135	50.077	49.891	49.815	46.096
1913	50.298	48.766	46.832	49.115	49.038	44.820	40.260	41.582	42.410	40.462	39.810	37.635	44.252

There were some fluctuations during August, but in the main the market retained a strong undertone, which was sustained by liberal orders placed from the United States. During the first half of September these orders continued, and in consequence thereof prices advanced to about 43 1/2 cents in this market. The London market became strong, but as soon as the support from this side was withdrawn prices eased off abroad and were lowered in sympathy with the movement on part of the domestic interests. They attained a level of about 41 cents at the beginning of October, and the market remained thereat, with small fluctuations downward during the entire month.

In November, a serious decline in standard copper acted adversely on the tin market, and as it had become evident that consumption in America was declining, the markets both here and abroad developed a weak tendency. Quotations were established the beginning of December at about £177 1/4 for spot and £178 1/8 for three months in London, and 39 cents here.

In the course of the month, the decline made further progress and reached the low point of 36 3/4 cents on Dec. 23. With the better senti-

ment prevalent, buyers of tin became more confident and a large business was done, in which consumers participated to a considerable degree. The London market, which necessarily obtained a good portion of these orders, was also favorably affected. This movement, which advanced prices to 37 3/4 cents, was, however, not maintained, and the market closed at the end of the year evincing an easier tendency and with quotations standing at £169 1/4 for spot and £171 1/8 for three months, and 37 cents New York.

METALLURGY.—Progress in the recovery of tin from its ores made noteworthy steps during 1913 in two directions, viz.: electric smelting, and chemical reduction processes.

Electric Tin Smelting.[1]—The supposition that the electric furnace is inappropriate for the smelting of tin ores, on account of its high temperature, is without foundation; for, as a matter of fact, the reduction of tin oxide by carbon requires a very high temperature, especially if the impurities are to be eliminated. The partial reaction produced in the reduction of tin oxide by carbon is

$$SnO_2+C=Sn+CO_2 \qquad (1)$$

but the reduction of at least two-thirds of the tin takes place according to the equation

$$SnO_2+2C=Sn+2CO \qquad (2)$$

The CO burns outside the furnace, and also acts as a reducing agent on traversing the charge. Under appropriate conditions, and after some hours of working, the reactions (1) and (2) take place equally. For this purpose we need theoretically 665 kw.-hr. per ton of ore. Moreover, we have to bear in mind the quantity of heat necessary to raise the charge to the required temperature, which amounts to from 1400 to 1600° C. in the reaction zone. The total consumption of energy per ton required may be estimated as follows:

	Kilowatt-hours.
Reduction	665
Slag	130
Specific heat	65
Radiation	130
Gases	150
Total	1140

The first experiments, conducted by A. F. Maclaren, in London, were followed, in 1911, by others undertaken by Doctor Walmsley, in the Northampton Institute. The first experimental furnace consisted of a chamber constructed of magnesite bricks, and having a lining of tar

[1] From "La Revista Minera y Metalúrgica de Madrid," 1913. (An article based on the experiments carried out by Mr. H. Harden in Cornwall, and described in the *Elektrotechnische Zeitschrift.*)

and magnesite. The arch had a charging hole. The inside diameter was 140 mm., and the total height 356 mm. Two inclined bars of carbon, each 13.5 mm. in diameter, served as the electrodes. The apparatus had no water circulation for cooling purposes.

In the first experiment the charge consisted of 9 kg. of ore, containing 63 per cent. tin, 2.3 kg. of coke-powder, and 2.3 kg. of flux, but, owing to want of sufficient current, only 5.5 kg. of ore were actually reduced. The consumption of energy amounted to 40 kw.-hr.—15 in heating and 25 in reduction. The fusion gave 2.4 kg. of tin in bars and 0.6 kg. of residues, corresponding to a yield of 85.5 per cent. The slag was irregular, and the consumption of current amounted to 8960 kw.-hr. per ton of tin. In another experiment, 2.9 kg. of pure tin and 1.1 kg. of residues were obtained from 7.3 kg. of ore, or a yield of 90 per cent., with a consumption of energy at the rate of 4900 kw.-hr. per ton. The metal contained 99 per cent. of tin, and a little iron, but no arsenic. When working under good conditions the slag ran well on tapping, was gray in color, had a vitreous luster, and contained, on an average, 0.5 per cent. of tin. The electrolysis of the slag, melted down with soda carbonate and dissolved in water, gave a good deposit of tin on iron cathodes, but the yield was not very high, and the consumption of energy was at the rate of 1820 kw.-hr. per ton.

After the preliminary tests, experiments were conducted on a larger scale. A shaft furnace was used containing three electrodes with carbon-bearers, and means of regulating the same. The formation of a direct arc was avoided. The charge formed a cone round the reaction zone, in which the electrodes burnt freely, surrounded by incandescent gases, which served as resistance. The loss of metal by volatilization was under 0.5 per cent. Tap-holes for metal and slag were at different heights. When the holes became closed by a slag very rich in iron, they were opened by the aid of an auxiliary electrode or the ox-acetylene flame. The furnace was first heated with a small fire of wood or coke. To 100 kg. of ore were added, on an average, 14 kg. of culm. At the commencement of the charge the furnace was worked with 60 volts and approximately 1000 amp. per phase; afterward the normal current was applied (40 volts, 2500 amp.). At the beginning of the charge the variations of current were relatively high, but ceased immediately when the electrodes burnt freely. After half an hour the first tapping of metal took place, the slag being tapped after the lapse of several hours. The slag was vitreous, dark green and fluid. After several hours' running, arsenides and sulphides of iron were introduced at regular intervals in order to avoid the formation of hard slags. By this means a metal containing 98 per cent. tin was obtained from very impure ores.

With ordinary Bolivian ore, containing 49.5 per cent. tin, and approximately 15 per cent. iron, an average yield of 92 per cent. was obtained, and it sometimes reached as much as 97 per cent. The liquid metal was refined in shaft furnaces containing iron tubes for the injection of air. By this simple means a commercial purity of 99.76 per cent. or more was obtained.

The three factors—yield of tin, consumption of energy and loss in slag—are inter-related within narrow limits. It is easy to obtain a slag containing only 0.25 per cent. tin, but then the process is not an economical one, as the consumption is 3000 kw.-hr. per ton of metal. On the other hand, with a slag containing 17 to 19 per cent. of tin, the consumption of energy can be reduced to 1300 kw.-hr. per ton of metal—but this, again, is not economical, as the rich slag cannot be worked afterward. An economical run can be obtained between these two extremes, with an extraction of over 96 per cent. of tin.

As a typical example we quote the average of the results obtained during a week's continuous run. The yield was 96.75 per cent., the consumption of energy was as follows:

	Kilowatt-hours.
Heating	1,178
Reduction	13,935
Total consumption	15,113

This corresponds to 2200 kw.-hr. per ton of tin. The consumption of electrodes amounted to 12.7 kg. per ton of metal. During some days the expenditure of current descended to 1700 kw.-hr. per ton. The mineral was very moist (15 per cent. water), which naturally increased the expenditure of energy.

By using two furnaces of sufficient size—the second one for the extraction of the tin from rich slag—the consumption of energy can be reduced to 1400 kw.-hr. per ton. The electric furnace yields a pure tin continuously, and from the first, which is certainly not the case with the reverberatory furnace. Moreover, as compared with the latter, the hand labor is less, as two workmen are sufficient for one furnace, and the space occupied by the furnace is much reduced. The consumption of electrodes is so small that it need not be taken into account. The electric process can be advantageously employed in places where the ores are good, but not very rich, and where waterfalls can be utilized for supplying the power needed.

Chenhall's Extraction Process.[1]—The Chenhall process is a chemical one, by which the metals contained in the ore are made soluble in acid solutions, and recovered thereform by precipitation.

[1] *Min. Jour.*, Sept. 6, 1913.

The ore is first crushed to a suitable size, then mixed with fine coal dust or other carbonaceous material, and heated in a closed furnace until the oxides of the metal are decomposed, leaving the metals in a metallic form distributed throughout the roasted ore in the form of fine metallic grains, care being taken to prevent reoxidation of the metal or metals during the cooling of the ore.

The gas disengaged during the roasting is collected and stored, and when the flow of gas from the mixture of coal and ore almost ceases, that which has been stored is returned to the furnace, so that during the whole of the time the ore is in the furnace it is in an atmosphere of coal gas. The coal mixed with the ore, being converted into coke, keeps the ore open, and allows the gas in the furnace to permeate the whole of the ore, as well as acting as a deoxidizing agent.

The cold roasted ore is afterward submitted to treatment with acid solutions. When tin is the predominant metal, the first solution consists of sulphuric acid and water, and should there not be sufficient iron in the ore to produce iron sulphate, a little iron is added; about 85 per cent. of the tin contained in the ore is dissolved out by means of this solution. The ore is now washed with water, and the final solution (hydrochloric acid and water) is added, by which the remaining tin is dissolved out. When any copper is present in the solution, which is always the case when it is present in the ore, it is precipitated from the solutions by metallic iron. Any insoluble material in the liquor is allowed to settle, and the clear liquors treated with sulphuretted hydrogen, which at once precipitates the tin in the form of sulphide, which is collected, dried, and heated, slowly at first and then to a dull red heat, which converts the sulphide into oxide of tin, and the sulphurous acid conducted to chambers for the production of sulphuric acid.

The waste liquors, after the tin has been extracted, are evaporated. The first solution for the manufacture of sulphate of iron, and the second chloride solution for the manufacture of red oxide of iron (rouge); by this means the excess of acid necessary through the presence of iron in the ores is converted into a saleable product, thus recovering the value of the acid so used.

The acid solutions are continually passed over fresh lots of roasted ore until practically all the acid is combined with the metals, and the ores receive a sufficient number of fresh acid solutions on them until the whole of the soluble metals are dissolved. The amount of acid consumed depends on the character of the ore, particularly on the amount of soluble materials contained.

Tungstic acid remains in the residue, and is extracted by an alkaline solvent, and recovered from the solution as very pure tungstic acid. The

loss of tungstic acid with the present methods of recovery of the wolfram in tin ores is 75 per cent. of the wolfram in the ore.

The plant needed for this process is that required for the manufacture of the two acids (sulphuric and hydrochloric). Suitable closed furnaces from which, during the roasting of the ores and their cooling, the air is excluded, and the presence of carbonated hydrogen gas is maintained during the roast. Means for effectively leaching the roasted ores, precipitating the tin, and recovering the by-products, including the acid used, are also required.

The cost of the process will vary with the metallic contents of the ore, and the amount of recoverable by-products. The roasting will cost from 4s. 6d. to 5s. 6d. per ton, and the leaching a further 1s. 6d. to 2s. per ton. The cost of the production of the necessary acid (sulphuric) will be say 45s. to 50s. per ton, and the hydrochloric about 80s. to 85s. per ton. A large percentage of the acid used will be recovered for further use in the process. Results of three tests on different ores were as follows:

Dolcoath submitted ore containing 71.75 lb. of metallic tin per ton. In treating this there appears to be a peculiarity, in so far that after the roasting process the value of the tin contents fell to 69.97 lb. per ton. This slight difference, however, is accounted for by the gain of weight due to the reagent used during the roasting. Out of this 69.97 lb. there was recovered 67.95 lb. of tin per ton, equal to a recovery of 97 per cent. Another sample from Dolcoath contained 36 lb., the recovery being 35.5 lb. per ton, or equivalent to over 98 per cent. recovery.

Carn Brea & Tincroft submitted ore containing 34.97 lb. of metallic tin per ton, the extraction being 33.87 lb. per ton, equal to over 96 per cent. extraction.

South Crofty sent ore containing 49.61 lb. of metallic tin per ton. The returns equalled 47.04 lb. to the ton, or an extraction of 95 per cent.

All of these tests were carried out in a laboratory plant, but now Mr. Chenhall is arranging a plant for the treatment, in bulk, of all classes of tin ore. He is also making good progress toward the recovery of tungsten associated with tin as wolfram.

TITANIUM

By James Aston

Three facts of greatest significance to the titanium industry, stand out most prominently as a result of development during 1913. Of primary importance is the investigation of J. T. Singewald,[1] on the economic value of the titaniferous iron ores of the Unites States. Correlative with this is the institution of experimental smelting of these ores on a considerable scale by the MacIntyre Iron Co. Thirdly, in its bearing upon the economic phases of the above development, is the marked falling off in the use of titanium as an addition agent in steel-rail manufacture.

Mr. Singewald was directed to study the possible utilization of titaniferous ores at a profit with present-day methods and apparatus, and under existing conditions. The results are chiefly negative, in that some of the deposits are not so extensive not as high in iron as generally supposed, and further that the association of the titaniferous mineral and the magnetite is so intimate as to practically prevent economical separation.

The investigator's field study has led him to the opinion that the possibilities of the titaniferous iron ores as a factor in the iron ore resources of the country, have been greatly exaggerated. In the ferromagnesian rich rocks, the situation is unpromising, as the deposits are small, irregular, and lean, and in general inaccessible. Even disregarding their titanium content, their character is such as to delay their utilization for a long time; and the nature of the titanium-iron association is entirely unfavorable to efficient separation.

Conditions are more favorable in certain coarser grained and richer ores, such as in Minnesota and Colorado. But above all others in importance are the titaniferous iron ore deposits at Sanford Hill, New York, and Iron Mountain, Wyoming. These two, the former in particular, are the titaniferous iron ore-bodies, and the only ones which can be of commercial value in the near future. At both places, the ore-bodies available for simple mining methods run to millions of tons, and are nearly pure aggregates of ilmenite and magnetite, with practically negligible gangue. The average compositon of the Adirondack ore is about 62.8 per cent. ilmenite, and would yield a magnetic separation concentrate of less than 7 per cent. titanium. The Wyoming ore runs about 49.8 per cent. magnetite, and 40.1 per cent. ilmenite, with a concentrate of less

[1] *Bull.* 64, U. S. Bureau of Mines.

than 10 per cent. of titanium. Both are of low phosphorus and sulphur content.

The problem of utilization has two lines of attack: First, by concentration methods, involving elimination of the titaniferous mineral; and second, by direct reduction of the ore by metallurgical processes. The possibility of the first named is of course in large measure dependent upon the second; that is, what content of titanium is the maximum feasible in furnace operation. As to actual separation, the experiments were promising and very disappointing in different instances, and no general rule as to behavior of the ores could be formulated. Where the ilmenite is in rather coarse grains, and isolated from the magnetite, the ores are amenable to separation by suitable crushing and magnetic concentration. But the economic feasibility of such procedure becomes less and less with fineness of texture of the individual grains, and where intergrowths and inclusions of the minerals prevail. Finally, and this appears to be all too frequently the case, separation becomes impossible where the ilmenite becomes an integral part of the magnetite molecule. The practicability of magnetic separation must be determined for individual cases.

The possibilities of direct smelting of titaniferous iron ores are as yet undetermined. The present limit seems to be 1 per cent. of titanium, because of a belief that undue amounts of fuel are required, and because of the accumulation of infusible titanium compounds which ultimately choke the furnace. The greatest interest, therefore, attached to the experiments of the. MacIntyre Iron Co. on what is probably the richest and most extensive deposit of titaniferous magnetite in the Adirondacks, in the Sanford Hill district. For the experiments, the Cedar Point Furnace of the Northern Iron Co., at Port Henry, N. Y., has been leased for 6 months. It is proposed to mix the titaniferous concentrates with ordinary magnetites in gradually increasing amounts (beginning with a 1 to 7 ratio) to the limit of commercial practicability.

The extent of the ore-body at Sanford Hill is give as 6,830,000 tons at a depth of 2 ft. below the adjoining surface.

Analysis of crude ore and concentrates are as follows:

	Ore, Per Cent.	Concentrate, Per Cent.
Iron	53.36	56.29
Titanic oxide	17.77	12.34
Silica	0.89	2.26
Alumina	5.81	4.52
Magnesia	2.41	1.48
Sulphur	0.22	0.10
Phosphorus	0.006	0.003

A concentration plant of 600 tons capacity is being erected at the foot of Sanford Hill, and surveys have been completed for a railroad to Fort Ticonderoga, on Lake Champlain, with grade all in favor of the load.

From here the state barge canal can be used for shipment. There are several water power sites on the property. It is expected that the ores will prove attractive to Eastern furnaces, once their usuability is thoroughly determined.

Latest advices are that up to the present time the proportion of titaniferous concentrate has not exceeded one-eighth; but that on resumption of operations, a start will be made with 25 per cent., and a gradual increase made to 50 per cent. of titaniferous ore.

The above-mentioned activities have done much, and promise to do more, to clear up the mysteries regarding titaniferous iron ore resources of this country. The popular impression of deposits of immeasurable extent and value, awaiting only some revolutionary process for their reduction, seems to be unfounded. The deposits are much smaller and less valuable than supposed, and it appears evident that the possibilities of utilization are along the lines of gradual development and adaptation of present processes and equipment. Commercially, too, the deposits will assume an importance largely in accord with the degree to which the product can meet the competition of the open market. Titaniferous pig iron might have some sale at advanced prices for certain classes of gray iron castings, although the advantages of titanium additions are at the present time a matter of dispute. As a material for steel making, titaniferous pig iron would have to meet direct competition of corresponding ordinary grades, since the ready elimination of the titanium during the conversion process would take away all benefit derived from the customary addition for purification during casting.

The electric furnace, of course, offers a revolutionary, and possibly successful method of utilization of the titaniferous ores. But here the greatest chances of success are in the manufacture of ferro-titanium, a product with very limited market. In fact, a great expansion of the market would be necessary to absorb even the alloy made from the tailings resulting from magnetic concentration as discussed heretofore. Actual production statistics show a decline in the use of titanium as an addition to rail steel, an important outlet. The tonnage of rails so treated is as follows:

	1909.	1910.	1911.	1912.	1913.
Tons of Rails Treated.....	35,945	256,759	152,990	141,773	47,655

The above falling off, too, is in the face of the widespread interest in piping and segregation in rail making, and an activity on the part of both maker and user toward the betterment of quality. Part of the decline may no doubt be accounted for by the quietness of the steel trade in the last half of the year; but there is no doubt that the progress of the open-hearth process and the decline of the Bessemer in rail making, coupled

with an uncertainty as to the actual benefit of the titanium addition, or at any rate a desire to allow sufficient time to prove its efficacy, have been weighty factors.

M. H. Wickhorst[1] has investigated the influence of titanium on Bessemer steel for rails, and finds that 0.1 per cent. of such addition is of benefit in reducing segregation in the upper third of the ingot, and thereby improving the quality of the rails from this section although there was increased piping; while there was no appreciable change in the quality of the rest of the steel. Additional amounts of titanium were of no materially greater benefit.

Ferro-titanium rails are sold at $1.50 to $2 above the standard price of $28 for Bessemer.

Other than for rails, there was some increase in the use of ferro-titanium additions to steel over the 400,000 tons so treated in 1912. However, a half million tons of steel treated with titanium as a cleanser will necessitate a supply of not to exceed 1000 tons of titanium, or 5000 to 6000 tons of the usual alloy. This is a mere drop in the bucket as an outlet for our titaniferous iron ore deposits.

Ferro-titanium is made in this country by the Titanium Alloys Manufacturing Co. of Niagara Falls, N.Y. Of the two classes made, the carbonless and the ferro-carbon, the former is of very little commercial importance, with domestic production and sale of but very few tons, and importation of less than a car load. The ferro-carbon titanium is less costly and is free from the aluminium which is inevitably present in the carbonless, and which is of detriment upon oxidation during addition to the steel.

Ferro-carbon titanium has an average titanium content of 15 per cent., and is quoted at from 8 cents to 12 1/2 cents per pound, depending upon quantity.

Aside from the titaniferous iron ores, rutile and ilmenite are mined to a limited extent for the manufacture of electrodes for arc lamps, for use as titanium oxalate as a mordant in wool dyeing, in the ceramic trade, and in the manufacture of ferro-titanium. The United States Geological[2] Survey reports that all of the rutile produced in this country in 1913, was mined in Virginia by the American Rutile Co. This company controls and works the deposits at Roseland, Nelson County. Three-hundred five tons of rutile of 94 to 96 per cent. TiO_2 were produced. The portion of the deposit worked contains considerable ilmenite, which is removed by milling and magnetic separation. Two-hundred fifty tons of rutile concentrates were thus produced during the year, but not all

[1] *Amer. Ry. Eng. Assn.*, 1913.
[2] F. L. Hess, *Mineral Resources of the U. S.*, 1913, Advance Report.

of this was sold. Prices ranged from $160 to $200 per ton, depending on quantity and purity. The highest price is paid by the ceramic trade.

The Virginia rutile deposits are described in a recent bulletin of the Virginia Geological Survey.[1] There are 3 districts, of which the Amherst-Nelson Counties rutile-ilmenite deposits are of greatest importance. Less than one-fifth of a mapped area of 170 square miles in this district shows rutile bearing formation. In many places ilmenite is found scattered over the surface as sand, or in loose masses, and there is practically an unlimited supply of very pure rutile which can be concentrated to yield a product of over 99 per cent. TiO_2. As early as 1878 an attempt was made to work these deposits for iron, but was soon abandoned. There were intermittent activities, chiefly in exploration and experimental development, until the American Rutile Co. began operations in 1900. Their properties comprise a large quantity of ore, probably averaging about 5 per cent. of the rock. Much of the output has been shipped abroad, but the demand has been limited and not enough to keep the mill in operation continuously. The General Electric Co. entered the district in 1907, but after operating for 5 years the plant was shut down, and is still idle.

In addition to the Amherst-Nelson Counties district, the Roanoke County ilmenite-apatite, and the Hanover-Goochland Counties rutile-ilmenite areas, were explored, and the latter is believed to constitute an additional commercial source of titanium mineral.

To supply any increasing demand for rutile, there are only four known localities in the world that promise to be important factors. In order of productive rank they are:

(*a*) The above Virginia deposits, especially the Amherst-Nelson.

(*b*) The Kragero area in southern Norway. This supplies much of the foreign demand, but does not approach the Virginia district in size, and the rutile is more irregular in distribution and of lower grade.

(*c*) The Bay St. Paul area in northern Quebec, Canada. Apparently quite pure rutile, but of irregular distribution.

(*d*) South Australia. A recently discovered deposit with very pure rutile, but probably not nearly so extensive as the Virginia area.

Beds of titaniferous magnetite on the Blackfeet Indian Reservation, Montana, are described by E. Stebinger.[2] There is a very considerable tonnage in scattered areas, and of varying thickness averaging 4 to 5 ft. of ore which could by hand sorting be brought to 50 per cent. iron content, although the average of available material is not over 30 or 40 per cent. The proportion of TiO_2 is considerable, about 12 per cent., and the deposit is thus of little commercial importance for use at present.

[1] *Bull.* 111 A.

[2] U. S. Geol. Surv., *Bull.* 540.

During the year Canada produced 5362 tons of titaniferous iron ore. Large deposits are reported in many localities of Ungava.

Titaniferous iron ore deposits in Hungary and Madagascar are reported and described.

Following are the tariff rates on titanium products under the new schedules of Oct. 3, 1913.

	Old.	New.
Ferrotitanium and metal.	25 Per cent. if value is $200 per ton or less. 25 Per cent. if value is above $200.	15 per cent.
Titanium alloy steel.	7/40 to 7 Cents per pound, according to value, and 20 per cent. if value over 40 cents per pound.	15 per cent.
Crude ore.	Free.	Free.

The Bureau of Standards[1] has determined the melting point of titanium of 99.9− purity, as 1794° C. ± 12.

J. W. Evans[2] describes experiments in making high-class tool steel direct from titaniferous magnetites. The materials, ore, charcoal, lime, pitch, tar, etc., are briquetted and smelted in an electric furnace. Test runs show a possibility of making a superior quality of tool steel at a cost not exceeding 3 cents per pound, and almost equal in efficiency to high-speed steels.

Cupro-titanium with about 5 to 12 per cent. Ti has been recently placed on the market to improve the quality of copper, brass, and bronze castings. It plays an analogous rôle in cleansing to that of titanium additions to steel.

Bibliography

Bonnefond.—Titaniferous Iron Ore Madagascar. *Bull. Soc. Ing. Civ.*, 1913.

Kellog, L. O.—Smelting Titaniferous Magnetite. *Eng. Min. Jour.*, Sept. 27, 1913.

Lake, E. F.—Titanium as Used in Steel Making. *Met. Chem. Eng.*, Mar., 1913.

Prassetsky.—Influence of Titanium on Open Hearth Steel for Rails. *Rev. Soc. Russe de Metal*, 1912.

Vendl.—Titaniferous Iron Ore in Hungary. *Foldt Kozl.*, Vol. XLII, 1912; *Jour. Chem. Soc.*, Vol. CIV, 1913.

Watson T. L., and Taber S.—Geology of the Titanium and Apatite Deposits of Virginia. *Bull. Va. Geol. Surv.*, III-A.

———. Symposium on Sound Ingots. *Bull. Amer. Inst. Min. Engrs.*, Feb., 1913.

———. Titaniferous Iron Ores in Port Henry Furnace. *Iron Trade Rev.*, Mar. 12, 1914.

[1] *Reprint*, 205.

[2] *Eng. Min. Jour.*, June 7, 1913.

TUNGSTEN

By C. G. FINK

The American tungsten industry in 1913 showed a marked increase over that of 1912 although it by no means approached the high record of 1910 which is still the banner year. In the following table the weights are given in tons of equivalent of ore carrying 60 per cent. of tungstic acid (WO_3) which is the commercial basis in this country.

PRODUCTION OF TUNGSTEN CONCENTRATE IN THE UNITED STATES. (a)
(In tons of 2000 lb.)

Year.	Production.	Value.	Average per Ton.	Year.	Production.	Value.	Average per Ton.
1904	740	$184,000	240	1909	1,619	$614,370	379
1905	803	268,676	334	1910	1,821	832,992	457
1906	928	348,867	376	1911	1,139	407,985	358
1907	1,640	890,048	543	1912	1,330	502,158	377
1908	671	229,955	343	1913	1,525	640,500	420

(a) Statistics reported by the U. S. Geological Survey. Figures for 1913 preliminary.

The price per pound paid for tungstic acid (WO_3), rises as the tungsten content of the ore increases (R. D. George, State Geologist, Boulder, Colorado). The following schedule was adopted, Dec. 1, 1912:

PRICES OF TUNGSTEN ORE, DEC. 1, 1912.

Tungstic Acid in Ore, Per cent.	Price per Pound of Tungstic Acid, Cents.	Tungstic Acid in Ore, Per cent.	Price per Pound of Tungstic Acid, Cents.
1– 4	5–11	35–39	28
5– 9	15–19	40–44	29
10–14	20	45–49	30
15–19	23	50–54	32
20–24	25	55–59	34
25–29	26	60	37½
30–34	27	.....	.....

The price per unit (20 lb. of tungstic acid, WO_3) during 1913 ranged from $6 to $7.50 for 60 per cent. ore or concentrates, as against $5.60 to $7.50 during 1912. The average value per ton for 1913 was higher than that for 1912 and approximated the value per ton of 1910.

Although the steel industry as a whole was fairly quiet the tool-steel and ferro-tungsten trade showed a healthy activity throughout the year.

The imports of tungsten and ferrotungsten in 1913 were 654.3 tons valued at $795,467. The imports for 1912 were 233 short tons of tungsten

and ferro-tungsten valued at $323,872 according to returns received at the Bureau of Foreign and Domestic Commerce.

Colorado.—Colorado (Boulder County) continues to be the chief producer of tungsten ore in the United States. According to F. L. Hess of the U. S. Geological Survey, the total output of this state in the past year amounted to 953 tons of ferberite as against 812 tons in 1912. The mineral occurs in veins associated with pegmatite. Most of the mines are small and require simple stoping. The largest producer in Boulder County is the Conger mine.[1] The mine was originally opened by an incline on the vein. A vertical shaft has now been sunk 550 ft. Three veins, the Conger, the Middle and the East have been developed. Most of the ore-bodies are ideal for convenient mining. They occur more or less lens shaped, pinching down to a narrow seam, then opening out to from 4 to 8 ft. frequently over a considerable length. Some of the ore-bodies have been stoped in a continuous body for 800 ft. The Conger ore is shipped by tramway to the Primos mill. This mill uses practically an all-sliming process. There are two 5-stamp batteries weighing 1000 lb. each and delivering each 3 1/2 to 4 tons per 24-hour day, crushing from 1 in. through a 20-mesh Ton-cap screen. The crushed ore passes through a series of Wilfley tables, settling tanks, vanners, Dorr classifier, and Prosser tube mill. The Primos mill uses about 200 gal. of water per minute. The regular day shift consists of one man for crusher, one for batteries, tables and vanners, two ragmen, drierman and foreman. The crusherman and drierman do not work at night.

The Wolf Tongue mill near Nederland follows coarse crushing as closely as possible. Classification is by means of three special small, shaking screens designed by William Loach (manager). The screen consists of an eccentrically operated galvanized iron hopper with a screen inside, so that the oversize is discharged to the table and the undersize passes out of the bottom of the hopper and onto the next screen. The slime is treated on Monell slimers which are working very satisfactorily. The concentrates are dried and shipped to the Firth-Sterling Co., McKeesport, Penna. The tungsten obtained from these concentrates is used almost entirely for making ferro-tungsten. Analyses of ferberite from the Nederland—Beaver Creek area varied as follows: tungstic acid, 60.98 to 74.13 per cent.; iron oxide, 19.13 to 24.14; manganese oxide 0.08 to 0.69; lime 0.35 to 1.28; silica, 0.71 to 16.10; aluminium oxide, 0.46 to 3.10; and magnesium oxide, nil to 0.59.

California.—The importance of San Bernardino County as a tungsten ore producer has steadily increased and next to Boulder County, Colorado, is the largest producer in America. More scheelite was produced in the

[1] Tungsten in Boulder County, Colorado. *Eng. Min. Jour.* 96, 99 (July 19, 1913).

Atolia district, San Bernadino County, than in any other district in the world. The Atolia Mining Co. controls most of the known depostis. A little scheelite has also been shipped from Randsburg, Kern County. Frequently the scheelite is associated with gold-bearing quartz. Some wolframite was produced near Ivanpah in the Clarke mountains.

OTHER STATES.[1]—In *Arizona* scheelite was produced in the Old Hat district, 40 miles north of Tucson. Excepting the Atolia district, Cal., this is the only district in the United States from which a production of scheelite is made. Some huebnerite was produced in the Arivaca region, south of Tuscon, and at Dragoon, east of Tuscon.

In *Nevada* a little huebnerite was produced at Round mountain.

In *Idaho* the Blue Wing district, Paterson Creek (Lemhi County) reported small shipments of huebnerite. The ore occurs in quartz veins in diabase shist. A mill of 100 ton daily capacity was erected to concentrate the ore.

In *South Dakota* a mill was erected at Hill City, South Dakota, and a small quantity of wolframite was concentrated and part sold.

FOREIGN COUNTRIES

NORTH AMERICA.—*Nova Scotia.*—In 1912, 14 tons of concentrated scheelite ore (72 per cent. tungstic acid) were shipped.[2] The shipments for 1913 were considerably larger (no final figures received). The only place at which the ore has been worked commercially is at Scheelite mines, Moose River district, Halifax County. Nine shafts have been sunk, ranging in depth from 30 to 120 ft. and no fewer than six distinct veins of mineral-bearing rock have been met with.[3] The mineral occurs in quartz veins cutting the quartzites and slates of the gold-bearing series.[4] The small mill is well equipped with modern machinery. A company called the Scheelite Mines, Ltd., with a capital of £750,000, has been formed and has taken over the mines from the syndicate.

A new discovery of tungsten ore in northern Ontario was reported at the close of the year.

SOUTH AMERICA.—*Argentine.*—The ore is mostly wolframite which is being shipped to Europe. The production for 1912 amounted to 638 tons.

Bolivia.—Wolframite was mined in the Province of Inquivisivi and in the Departments of Oruro, Cochabamba and Potosi. The mineral is associated in small veins with tin, bismuth, silver and copper ores. The ore assays 5 to 20 per cent. tungstic acid (WO_3). The concentrates run

[1] U. S. Geological Survey, *Bulletin.*
[2] *Can. Min. Jour.*, 34, 189.
[3] G. B. Barham, *Can. Min. Jour.*, 35, 54.
[4] V. G. Hills, Tungsten Mine in Nova Scotia. *Min. Sci. Pr.*, 106, 448.

between 60 and 70 per cent. There are about thirty small mines and the industry is increasing. Practically all of the ore is exported.[1] The production in 1912 was 497 tons.

Peru.—There is every indication that Peru will become an important tungsten ore producer. Yet the development of the mines has been greatly hampered through lack of proper transportation facilities. The properties in the Conchucos district were practically the only producers in the Republic. The mines are those of the Conchucos Tungsten Co., the Pelagatos Mining Co. and the C. Weiss and Co. of Lima. The Pelagatos Co. produces about 100 metric tons of concentrate per year. The Pelagatos ores run 25 per cent. copper, 25 oz. silver and 3 per cent. tungstic acid (WO_3).[2] The principal vein is about 32 in. wide. The Weiss mills turn out about 100 tons of concentrates annually. Their main ore supply is brought from the Huaura Mountain mines. The underlying rock formation throughout the district is granite with superimposed layers of quartzite and slates, in which layers the ore is found. The deposits of the greatest richness are found on the dividing line between the slate and the granite and the granite and the quartzite. Peru's tungsten ore (huebnerite) production amounted to about 300 tons in 1913 as against 211 tons in 1912. Most of the ore is being shipped to London. Here it is quoted at 33s. 6d. per unit of tungstic acid, in a 1000 kilos of mineral, with a minimum of 65 per cent. tungsten.

EUROPE.—*Portugal.*—By far the largest producer in Europe is Portugal. In 1912, 1332 tons of concentrates were shipped showing a decided increase over the years 1910 and 1911. The ore is mostly wolframite. Portugal promises to be a greater producer than the United States.

British Isles.—In 1912, 193 metric tons of wolframite were produced. The mines are situated at Carn Brea, Illogan and Scorrier.

Spain.—During recent years Spain's production has fluctuated between 100 and 200 tons of wolframite. The deposits of the district of Oliva de Jenez and Zahinos in the province of Badajos occur in crystalline rocks, gray and greenish gneiss with interstratified schists and bedded veins of quartz, the latter enclosing wolframite.[3] The principal mine is the La Virgen de Gracia. In the northwestern part of the property a rich alluvial deposit extends over an expanse of about 7 acres netting 6 kg. wolframite per cubic meter.[4] The wolframite pebbles are usually about 1 to 5 c.c. in size. Many specimens are much larger and weigh 2 to 4 lb. apiece. In the upper beds of the Alcornocosa hill wolf-

[1] *Can. Min. Jour.*, 34, 405, 1225.
[2] A. H. Hale, *West Coast Leader*, April 16, 1914.
[3] *Min. Jour.*, 1914, 1121.
[4] *Eng. Min. Jour.*, 97, 27.

ramite is often associated solely with hematite. The wolframite occuring in the quartz is in the shape of nodules of various sizes. At places where the thickness of the vein is reduced to a few inches, wolframite has been taken out in solid plates. In an exploratory cut 17 tons of wolframite were obtained from 450 cubic meters. From reports received it appears that the Badajos region is rapidly gaining in importance as a tungsten producer.

ASIA.—*Burma and the Shan States.*—The most notable event of the year in the world's tungsten industry is the remarkably large production of ore in Burma. The production has been almost twice that of the United States. Accordingly *Burma is now the largest producer of the world.*

Tungsten ores have been met with in practically every part of the districts of Tavoy and Mergui and a large number of concessions are being worked. Wolframite is the main object of exploitation, cassiterite being a sort of by-product, although at times the tin ore forms a larger percentage of the alluvial deposits than the wolframite.[1]

Although the Chinese have been working the district for tin for more than 300 years the production of tungsten dates from 1910. The mineral is carried as a drift in the alluvial and in a milky white quartz gangue, highly crystalline. The wolframite itself is massive in its crystallization.[2]

The production of wolframite in 1910 amounted to 370 metric tons (60 per cent. WO_3); in 1911, 1020 tons; in 1912, 1900 tons and for 1913 the preliminary estimate is 2700 tons. The total cost of producing and delivering a ton of 68 per cent. concentrate in England is $313.76. When the price is $7.30 per unit (1 per cent. of WO_3) the profit aggregates $180 per ton. The average concentrates from the float workings contain about 65 per cent. of WO_3.

Japan.—The annual output of Japan (mostly wolframite) has remained practically constant within the last 6 years, amounting to an average of 250 tons. The total production for 1912 amounted to 205 metric tons (60 per cent. WO_3). The production of scheelite and reinite (ferberite replacing scheelite) averages 35 metric tons per year. The wolframite is treated as 72 per cent. tungstic acid.[3]

AUSTRALASIA.—*Victoria.*—The Mt. Murphy Wolfram Mining Co., Benambra, has undertaken extensive operations at Mt. Murphy, north of Omeo. Two tunnels have been cut into the mountain. The production (wolframite) for 1913 is estimated at 50 metric tons.

Queensland.—Since 1906 the Irvinebank Co. has treated 24,745 tons of ore yielding 666 tons of concentrate worth $300,000. The con-

[1] H. B. Osborn, *Daily Consular and Trade Report*, 1913, 1740.
[2] *Min. Jour.*, Sept. 6, 1913.
[3] *Min. Jour.*, 96, 302.

centrates average 78.6 per cent. WO_3. The iron oxide present amounts to 18 per cent. manganese oxide, 6 per cent.[1] The mines of the Irvinebank are situated at Mt. Carbine. The ore consists mostly of quartz accompanied by considerable feldspar. It assays 1.75 per cent. tungstic acid. As a rule the wolframite is non-crystalline. The mill of the company has been fitted out with Card, and Krupp tables, Luhrig vanners, a Wheeler pan, an upward current classifier and a series of conical settlers. The ore is very friable. The total production of concentrate (on a 60 per cent. WO_3 basis) amounted to 860 metric tons in 1912.

A new mineral, Chillagite, was discovered at Chillagoe.[2] It is an isomorphous mixture of lead tungstate and molybdate. According to Smith and Cotton[3] chillagite is a lemon-colored crystalline mineral (density 7.30) containing 22.3 per cent. WO_3, 22.0 per cent. MoO_3, 54.3 per cent. PbO, a mixture of wulfenite ($PbMoO_4$) and stolzite ($PbWo_4$).

New Zealand.—New Zealand exported 135 tons of scheelite in 1912 valued at $64,867. Active workings in 1913 occurred in two provinces, Otago and Nelson. The Golden Point mine in Otago is about 2000 ft. above sea level.[4] The lodes are very much faulted and hard to follow requiring careful timbering. The most favorable indication of a pocket of rich ore is a footwall of hard black slicken-sided schist very highly polished and mineralized. The treatment at the mines is to bag all firsts and send to surface, seconds being sent out with ordinary ore to the mill. The firsts are then hand knapped up to 60 to 65 per cent. WO_3 and bagged for shipment, rejects being passed to mill for treatment. The cost of operation of the mine is comparatively low: for stoping, development and tramming 7s. 8.8d. per ton crushed (mine total). The cost of the mill totals: 5s. 8.9d. per ton which includes the cost of the cyanide plant. One thousand tons tails have been cyanided at a cost of 2s. 2 1/2 d. per ton treated. The mill has a capacity of 30 tons per day. The average low-grade scheelite concentrates assay 30 to 40 per cent. $CaWO_4$, 50 to 55 per cent. pyrite, 10 per cent. silica, 2.5 oz. gold. The magnetic separation consists in thoroughly drying the concentrates and then roasting the pyrite to the magnetic sulphide stage and screening. In the separation operation 15 per cent. of the $CaWO_4$ is deflected with the iron. Accordingly this first iron product is put through a second re-treatment and roast. The scheelite product is brought up to 61.2 per cent. WO_3.

New South Wales.—The tungsten ore production in 1913 showed a decrease over 1912: Scheelite, 44 metric tons valued at £4457; wolframite, 126 tons, valued at £13,037. The figures for 1912 were 56 tons and

[1] L. C. Ball, *Min. Sci. Pr.*, May 10, 1913, p. 696.
[2] A. T. Ullmann, *Jour. Proc. Soc. New So. Wales*, 46 (2), 186.
[3] *Ibid.*, 46 (2), 207-217.
[4] C. W. Gudgeon, *Austral. Min. Stand.*, Nov. 13, 1913.

172 tons respectively. The mineral is found in patches or pockets. The Damfino and the Bulldog mines were the chief producers.

Tasmania.—In 1913, 68.07 tons of wolframite valued at £7040 were produced as compared with 66.49 tons valued at £6601 in 1912.

AFRICA.—Toward the close of the year, German southwest Africa reported finding valuable wolframite deposits near Klein Kharas and Nankeis. Small parcels of wolframite and scheelite were mined in several places in southern Rhodesia.

THE WORLD'S OUTPUT OF TUNGSTEN ORES

The following table shows the production of tungsten ores in all important producing states of the world. Noteworthy is the rapid growth of the tungsten mining industry in Burma, in Peru and in Portugal. The total world's production for 1913 is estimated at more than 10,000 metric tons (60 per cent. concentrates).

TABLE IV.

Metric Tons; 60 Per cent. WO_3.

Country.	1909.	1910.	1911.	1912.	1913.
North America:					
United States	1469	1655	1035	1210	1390
South America:					
Argentine	817	751	621	638	(a)
Bolivia	152	210	336	497	(a)
Peru	.....	14	52	211	300
Europe:					
England	382	278	264	193	(a)
Portugal	554	1030	980	1330	1380
Spain	129	153	96	150	200
Asia:					
Burma	.....	370	1020	1905	2700
Japan	265	250	261	205	(a)
Australasia:					
Queensland	617	1040	682	860	264
New South Wales	392	374	465	271	209

Statistics reported by the U. S. Geological Survey and foreign consuls.
(a) Statistics not available.

TECHNOLOGY

Tungsten Metal.—Tungsten metal for use in the steel industry, when prepared by the reduction of the acid (WO_3) with either carbon or carbon monoxide usually results in metal containing appreciable percentages of carbon. And the value of the metal to the steel man depreciates rapidly with the increase of the amount of carbon. The Electric Furnaces and Smelters Co., Ltd., introduced an improved reduction method by employing a mixture of 75 parts of tungstic acid, 7 to 10 parts of ferro-silicon, and 14 to 18 parts of calcium carbide. Toward the end of the

heat, lime and a little fluorspar are added and the temperature increased to 2800 to 2900° C.

Ductile Tungsten.—Drawn tungsten wire is now used by all of the large tungsten lamp manufacturers of the world. Owing to the ductility and rigidity of the drawn tungsten filaments the lamps with brittle filaments made by the old "paste" processes have disappeared entirely from the market. For the manufacture of tungsten wire the crude yellow tungstic acid (WO_3) must undergo careful purification. According to one of the methods the crude WO_3 is dissolved in ammonia and the solution then evaporated until most of the tungsten has crystallized out as ammonium para-tungstate. The crystals are carefully washed and dried and then heated to expel the ammonia leaving pure WO_3 behind. This is then reduced at about 1000° C. by either pure carbon or hydrogen. An amorphous grayish-black metal powder is obtained which is filled into a mold and pressed into bars. These bars are very fragile and to facilitate their handling they are heated to about 1300° C. in an atmosphere of hydrogen. The metal particles are thereby sintered together. The bars are then heated in hydrogen to almost the melting point by passing through the bars a large electric current. The bars are then swaged hot down to 30 mils. From there on the metal is drawn hot through diamond dies down to filament sizes. For the manufacture of tungsten plates or other forms the bars are forged or rolled hot.

The Half-watt Lamp.—In the tungsten lamp industry, the year is marked by the introduction of the gas-filled lamp. By winding the filament into the shape of a helix and concentrating it to a small space within the bulb and by introducing an inert gas (nitrogen) into the bulb, the commercial efficiency of the lamp was increased to 0.5 watt per candle. The nitrogen gas greatly reduces the speed of evaporation of the tungsten metal from the surface of the filament.

Properties of Tungsten.[1]—The melting point of the pure metal was very carefully determined by M. v. Pirani and A. R. Meyer by four different methods, involving optical and electrical measurements. The mean value is 5612° F. or 3100° C., accurate within ± 60° C. This value agrees admirably well with that found by Langmuir, 3177° C. At ordinary lamp efficiency (1 w.p.c.) the vapor pressure of tungsten was found to be 5×10^{-8} (Langmuir). The electrical resistance of the filament at 2100° C. (1 w.p.c.) is about 14 times that at room temperature (M. v. Pirani). The experiments of O. W. Richardson proved that the current through the tungsten filament is carried by electrons entering the metal from outside points of the circuit. Chemically the pure metal is very stable. It is insoluble in all of the common acids. It is soluble

[1] See MINERAL INDUSTRY, XXI, 848.

in mixtures of hydrofluoric and nitric acids and in fused alkali nitrates, nitrites and peroxides.

New Uses.—Tungsten needle points have been successfully tried out with sound reproducers of the Victor talking machine, and found superior to ordinary steel points. Chapman and Bryant[1] used tungsten wire 0.0008 in. in diameter, in place of silk or quartz for suspendingthe declination magnet (50 grm.) in their magnetometer. The instrument thus equipped gave very accurate readings.

The production of tungsten contacts for spark plugs and voltage regulators has increased rapidly. The new X-ray tubes with the tungsten metal targets have met with great favor by the medical profession. The new tubes can be operated for hours without showing an appreciable change in either the intensity or the penetrating power of the rays.[2]

Tungsten Alloys: Ferro-tungsten.—By far the greater consumption of tungsten, over 85 per cent., continues to be in the production of ferrotungsten for high speed and other special steels. Although the exceptionally valuable properties of tungsten steels were recognized as early as 1855, nevertheless a world-wide adoption of these steels did not take place until within the last 10 to 12 years. With tungsten-steel cutting tools it is easy nowadays to get 300 ft. of chip per minute whereas with the best carbon steels 100 ft. is considered exceptional service. Many of the modern high-speed tools contain from 14 to 19 per cent. of tungsten. Besides tungsten these tool steels contain chromium and vanadium.

Up to the time of the introduction of the electric furnace (1900) ferrotungsten was made by the crucible process. Since then most of the alloy is made electrically. In the crucible process the tungstic acid (WO_3) is mixed with the proper amount of carbon and iron. In some works tungstic acid is first reduced and then alloyed and the product contains up to 60 per cent. tungsten. In the electric furnace process wolframite or scheelite concentrates are reduced with carbon in an arc furnace. "The process is generally an intermittent one, that is, the reduced charge is tapped from the furnace before another charge is added, or the charge is let solidify and chiseled out of the furnace.[3] The reduced alloy is either decarbonized with refining slags in the same furnace or melted and refined later in another furnace. Most of the manganese is volatilized. Scheelite is more difficult to reduce and very sticky basic slags result. There is a greater loss in its reduction so that it does not command as high a price as wolframite, ferberite, or hubnerite. Scheelite therefore sells for about $1 less per unit."

Keeney recommends a furnace lined with magnesite having one upper

[1] *Nature*, **92**, 585.
[2] Coolidge, *Phys. Rev.*, **2**, 409–30.
[3] R. M. Keeney, *Trans. Am. Electrochems Soc.*, **24**, 127.

graphite electrode and a conducting hearth of iron rods imbedded in magnesite. Phosphorus and sulphur are easily slagged even when the percentage is high in the ore. Electric ferro-tungsten contains from 50 to 80 per cent. tungsten and 0.5 to 4 per cent. carbon.

R. Becker has patented a tungsten steel containing 15 per cent. cobalt (U. S. Patent 1081263).

There has been some agitation in favor of erecting ferro-tungsten plants in Colorado but the scheme is not yet feasible in spite of cheap power, on account of the high freight rates on ferro-alloys, as compared with the low rates on 60 per cent. concentrates.

Duralium is the name given to an alloy of aluminium and tungsten (2 to 3 per cent.). The alloy is very much harder than aluminium metal.

Other Tungsten Alloys.—F. de Buigne patented a new type metal composed of 10 parts of tungsten alloyed with 10 parts of copper and 80 parts of aluminium. Bresler, Hubers and others have taken out patents on tungsten-thorium alloys containing low percentage of the latter. L. Freiherr[1] describes a method of making a ductile tungsten alloy containing about 0.8 per cent. thorium.

Bibliography

Baumnauer, H. F.—Tungsten and its Technical Application. *Bayer, Ind. u. Gewerbebl.*, 1912, 141; *L'Industria*, **26**, 414; *Ind. Chim.*, **12**, 343–4.

Becker, R.—Tungsten Steel. U. S. Patent 1081263.

Becket, F. M.—Purifying Fe tungstate or maganate ores by treating with H_2SO_4 to remove P from the ore. U. S. Patents 1082566 to 71 incl. Dec. 16, 1913.

Carne, J. E.—The Tungsten Mining Industry in New South Wales. *Bull. Imp. Inst.*, **10**, 688.

Chapman, S., and Bryant, W. W.—Wire Suspensions for Magnetometers. *Nature*, **92**, 585; Jan 22, 1914.

Coolidge, W. D.—A powerful X-ray Tube. *Phys. Rev.*, **2**, 409.

Edwards, E. T.—Composition of High-Speed Tool Steel. *Iron Age*, **89**, 957–60.

Fink, C. G.—Applications of Ductile Tungsten. *Jour. Ind. Eng. Chem.*, Jan., 1913, p. 8; *Chem. News*, June 13, 1913, p. 282.

George, R. D.—Tungsten in Colorado. *Eng. Min. Jour.*, Jan. 18, 1913, p. 186.

Gudgeon.—Scheelite Mining in New Zealand. *Austral. Min. Stand.*, Nov. 13, 1913.

Haenig, A.—Modern Iron Alloys and Their Application to the Iron and Steel Industries. *Elektrochem. Zeit.* **20**, 189–190, 211–213.

Hills, Victor G.—Tungsten Mining in Nova Scotia. *Colo. Sci. Soc. Proc.*, **10**, 203–10 (1912).

Kruh, O.—The Production of Drawn Tungsten Wire. Electr. **73**, 844, *Elektrotechnik u. Maschinenb.*, **31**, 313, 338.

[1] *Metall u. Erz*, **10** (I), 844.

LANGMUIR, I.—Vapor Pressure of Metallic Tungsten. *Phys. Rev.* **2**, 329–42.

LANGMUIR, IRVING AND ORANGE, J. A.—The Nitrogen Filled High Efficiency Tungsten Lamp. *Proc. Am. Inst. Elec. Eng.*, **32**, 1895; *Elec. World*, **62**, 798.

LUMMER.—Temperature of Tungsten Filaments. *Jour. Gasbel.*, **56**, 687.

MEY, KARL.—The A. E. G. Nitra Lamp. *Electr.* **72**, 320.

MOORE, R. W.—Ductile Tungsten. *Met. Chem. Eng.*, **6**, 186–7.

MUELLER, N. L.—Tungsten and the History of its Ductilization. *Zeit. c angew. Chem.*, **26**, 404, 422.

PIRANI, M. v.—Specific Resistance and Absorptive Power of Tungsten at High Temperatures. *Physi. Zeit.*, **13**, 753.

ROGER-VASSELIN.—Tungsten Projectiles. *Bull. soc. encour. ind. nat.*, **121**, 220.

SCHLESINGER, G.—Progress of the German High-Speed Tool Industry. *Stahl u Eisen*, **33**, 929.

ZIEGENBERG, R.—The Half-Watt Lamp. *Zeit. Beleuchtungsw.*, **19**, 430, 445.

URANIUM AND VANADIUM

By Siegfried Fischer

Uranium.—Up to the present time uranium is of commercial value only as far as its radium content is concerned. Besides radium most of the uranium ores carry other radio-active substances such as actinium, polonium and ionium. At the Gif works in France, ores containing these elements are treated so as to obtain them separately. Outside of the chemicals uranium has a small field of usefulness. It is used to some extent in the glass and porcelain industry as a coloring medium. A German firm is putting on the market ferro-uranium to be used in the manufacture of steel. England is also interested in uranium steels and, as a permanent supply of ferro-uranium is guaranteed by Messrs. Geo. G. Blackwell, Sons & Co., Ltd., of Liverpoool, trials on a larger scale will be made in the steel industry. The reason for the lack of interest shown to the use of uranium in making steel was mainly due to the fact that the cost of production of ferro-uranium was far above that of ferro-tungsten. The properties of uranium and tungsten steels being similar, and the cost of ferro-tungsten being less, uranium could not compete with its rival. Uranium is also being used in the manufacture of organic dyes. It has been found that organic dyes containing the hydroxyl group will form new dyes with UO_2. The quantity of uranium used for all these purposes is, however, far below the amount that could be supplied and it is a desireable thing to find new commerical uses for this element.

Sources.—New deposits of uranium-bearing minerals are few. It is said that some pockets of uranium ore have been found on the ground of the Minnesota-Nevada Copper Mining Co., at Wabuska, Nev. Also some new veins of ore carrying autunite and tobernite have been located in the Schwarzwald, Germany. The main sources of uranium are as in previous years, pitchblende and carnotite. It is of interest to know, that during the year 1913 a definite formula for carnotite has been found. It has the following structure: $(Ca, K_2)\ (UO_2)_2\ (VO_4)_2$ and contains 18 per cent. U_3O_8 and 56 per cent. V_2O_5. Much prospecting is being done to find new minerals containing uranium. The Canadian Government has offered as an inducement $25,000 for the discovery of new ores containing uranium, in the Dominion.

Technology.—In an article published in the June, 1912, number of *Metallurgical and Chemical Engineering*, the necessity and means of

concentrating carnotite ores was published for the first time by S. Fischer. That this was possible and necessary was again shown by the work done by the Bureau of Mines, which is published in *Bulletin* 70 which gives with considerable detail all the known processes for the obtaining of the uranium for further treatment for radium, and as they are not new, no further mention will be made regarding them.

Market.—The steady demand for radium is increasing the demand for uranium ores. The American market is paying on the basis of the uranium content only and has raised the price per unit of U_3O_8 so as to allow for any vanadium in the ore. The price varies per pound from $1.00 for an ore carrying 0.6 per cent. of U_3O_8 to $4.60 for one carrying 3.15 per cent. U_3O_8. A German firm claims to have bought pitchblende ore running 30 per cent. pitchblende at $0.81 a pound. The slimes obtained from the treated ore in Portugal sell from $22 to $30 a ton.

United States.—The following mines are producing pitchblende to date: the German and Belcher mines, the Kirk, Wood and Calhoun mines in Gilpin Co., Colo. The carnotite deposits commercially producing are those of the Paradox Valley, and surrounding districts, Colo., and the Green River district in Utah.

Production: Ore shipped in terms of U_3O_8 and metallic U.

1911	25 tons	21.2 tons
1912	26 tons	22.0 tons
1913	38 tons	32.3 tons

The figure for 1913 shows an increase of nearly 50 per cent. The output would have been greater had not one of the principal foreign producers had to restrict its operations due to the factory at Liverpool not having been completed.

Australia.—Production between 4 and 5 tons of pitchblende.

VANADIUM.—The increasing demand for vanadium for the making of vanadium steels is adding importance to this metal. Besides its beneficial qualities in the metallurgy of steel, it has attained not a little importance in the medical field. Under the name of vanadin, a double salt of vanadium with postassium chlorate is being used as a medicine. With aniline it is used as a brick dye. V_2O_5 replaces platinum as a catalyte in the contact process for sulphuric acid. It is used as a developer in photography. Vanadium chloride is used as a mordant. Vanadates with tannic acid give a waterproof black ink, and vanadium salts are used as coloring agents in the glass industry.

These uses are however small compared with the use of vanadium in the steel industry. The beneficial properties ascribed to its use in steels are great toughness and increased torsional strength. It is therefore

alloyed with steels used for automobile parts, gears, piston rods, tubes, boiler plates, tires, transmission shafts, bolts, gun barrels, gun shields, and forgings of any kind requiring heavy wear and tear. The amounts of vanadium used for such steels varies from 0.1 to 0.4 per cent. Other alloys with vanadium are bronzes and german silver used for castings. In cast iron vanadium increases the strength 10 to 25 per cent.

Sources.—Three quarters of all the vanadium produced is made from patronite, an impure VS_3 mined in Peru by the American Vanadium Co. The hardness of this mineral is 2.5 and its specific gravity 2.65 to 2.71. The ore contains 20 to 30 per cent. V_2O_5, and when roasted the V_2O_5 content is raised to 40 per cent. Typical analyses of the ore are by

K. Smith.	Per Cent.
VS_3	39.8
MoS_2	1.6
NiS	1.5
FeS_2	4.1
S	30.6

Handy.	Per Cent.
V	16.0
MoO_3	0.5
Fe	2.5
S	54.1

Hillebrand.	Per Cent.
V	19.5
Mo	0.2
Ni	1.9
Fe	2.9
S	58.8

The Peruvian deposits are located at Quisque, Minasragra, Province Pasco, Department Junin. They cover an area 3.5 by 1.5 miles, and are 16,000 ft. above sea level.

Vanadium is also obtained in considerable quantities from carnotite. A further source of vanadium are the vanadinite deposits of San Marta, Estramadura, Spain. At present very little is being done with the vanadinite deposits in Grant County, New Mexico. The last commercial sources are the vanadiferous sandstone deposits of Colorado and the roscoelite at Newmire, Colo. Due to the Peruvian ore roscoelite is losing in importance as a commercial vanadium ore.

The ashes of some coals show an appreciable amount of vanadium:

Coal Deposits in	Per Cent. Ash.	Per Cent. V_2O_5 in Ash.
Peru: Yauli	7.56	3.87
Chile: Iqique	3.50	16.4
Argentine Rep.: Mendoza	0.63	38.2
United States: Oklahoma	1.03	19.3

The ashes of the Peruvian coals are being sold but their sale is slowing up due to the activities of the American Vanadium Co. in Peru.

Vanadium is also found in Mexico, Australia and Portugal, but none of the minerals found are commercially utilized. Some mineral oils of America, Peru and Argentine show vanadium.

Technology.—The process devised by W. F. Bleeker for the extraction of vanadium from patronite is as follows: ore is pulverized, then mixed with a flux which will render the vanadium soluble after roasting; the roasted

product is leached with water giving the vanadium as vanadates or vandyl salts. The residue is leached with dilute acid to dissolve any insoluble vanadium compounds, and the solutions are mixed to obtain a neutral solution. Copper sulphate or any other copper salt is added to the solution and this precipitates the vanadium as copper vanadate which is filtered out. It is then reduced to ferro-vanadium.

Method used by the Primos Chemical Co. at Newmire, Colo.: the ore is weighed and mixed with salt. This mixture is then coarsely ground and dried down to 1 per cent. moisture in a drier. The somewhat caked material is then ground to 20 mesh and roasted in a furnace for 3 hours. From the bottom of the furnace the product is conveyed to leaching vats where it is leached with water. The solution containing the vanadium as vanadate is then treated with ferrous sulphate giving vanadate of iron. This is filtered off, dried and shipped to Pennsylvania where it is reduced to ferro-vanadium.

Ferro-vanadium:	25 to 50 per cent.	V	made by the Société
	0.3 to 5	C	Electro-Metallurgique.
Ferro-vanadium:	30 to 35	V	Goldschmidt Thermite Co.
	No	C	

Ferro-vanadium with 33 per cent. V melts with Fe at 1400 C.
Commercial Alloys: 97 Cu and 3 V.
Ni and 18–25 V.
Aluminium bronze: 0.5 V, 94.5 Cu, 0.5 Al.
Manganese bronze: 0.03 V, 58.6 Cu, 38.5 Zn, 14.8 Al, 0.48 Mn.
Manganese bronze: 1.0 Fe.

Market.—The market price of ferro-vanadium is $2.50 per pound of vanadium contents. Vanadium ore running 15 per cent. V_2O_5 sells per ton, minimum, $150 and maximum, $180.

Ore has been offered on the German market at $2.38 per kilo (2.2 pounds). The ore is claimed to come from Peru.

All the vanadium ores of commercial value come from Peru, the United States and Spain. The ore from Peru is treated in America, by the American Vanadium Co., who control the market.

United States.—The vanadium shipped in the ores for the year 1913 was 914 tons of V_2O_5 which is equal to 412 tons of vanadium metal. The production of ferro-vanadium has increased 24 per cent. It costs approximately $70.00 to mine and deliver 1 ton of carnotite ore in Europe.

The chief ore producers are: the American Vanadium Co., Primos Chemical Co., Colorado Carnotite Co., Curran & Hudson Co., Standard Chemical Co., McKeever & Co., Arden Wilson & Co., and the General Vanadium Co.

Peru.—According to a reliable source the output of ore from Peru was somewhat restricted for the year 1913. The crude ore before being

shipped to America is calcined, raising its vanadium content to between 40 and 50 per cent. V_2O_5.

Bibliography

Arnold, J. O. and Read, A. A.—The Chemical and Mechanical Relations of Iron, Vanadium and Steel. *Iron and Coal Tr. Rev.*, 1912.

Curran, T. F. V.—Carnotite. *Eng. Min. Jour.*, 1913.

Fischer, Siegfried.—The Carnotite Industry. *Trans. Am. Electro-Chem. Soc.*, **25**, 361 (1913) .

Moore, R. B., and Kithil, K. L.—*Bulletin* 70, Bureau of Mines.

Rickard, F.—Pitchblende from Quartz Hill, Gilpin Co., Colo. *Min. Sci. Pr.*, 1913.

Skinner, R. P.—Production of Uranium and Vanadium Ores. *Min. Sci.*, 1913.

————. American Vanadium Facts. 1913 and 1914.

ZINC

By R. L. Bartlett

The total production of primary spelter by ore-smelters in 1913 was 346,676 short tons. There was also produced about 50,000 tons of secondary spelter, this being produced from such sources as drosses, skimmings, and old metals. This latter figure is given in round numbers, as owing to the difficulty of securing complete data, the exact amount cannot be ascertained.

As usual, Missouri had the largest output, even though the output showed a decrease of 20,000 tons from 1912. Colorado was next with a slight increase over the preceding year, and Montana was third, with a gain in spelter production of over 150 per cent. Good gains were also made by New Jersey and Oklahoma.

While the total production of spelter shows a gain over 1912, the profits to the zinc industry were much less, owing to the much lower prices prevailing during the year. The year 1913 opened with a falling market, and the decline in price continued until June, at which time there was a slight rally, but it was short lived, for with the passage of the tariff bill, another decline set in.

The reason for the increase in spelter production in 1913 over 1912, is that the high prices prevailing in the former year stimulated zinc mining, and owing to what may be termed the "inertia" of mining, heavy production continued for a considerable time after the decline from the high prices which had furnished the stimulus.

It is probable that a much larger stock of concentrates was held by the mining companies at the end of 1913 than at the end of 1912, and for this reason the actual increase in production should probably be more than is estimated.

Calamine ores were in strong demand by smelters, owing to the increasing cost of natural gas, and as low as 18 per cent. ores were accepted.

In spite of the low prices, Montana more than doubled its production, and in view of this increasing competition from the West, which seems able to produce profitably at prices at which many older eastern districts cannot meet their payroll, the outlook for the latter is somewhat gloomy. Another disquieting feature is that the present tariff has made possible importations of cheaper ore, so soon as Mexico shall have settled to a point where mining can be resumed with safety.

EXPORTS OF ZINC ORE AND ZINC OXIDE FROM THE UNITED STATES. (a)

Year.	Ore.			Oxide.		
	Short tons.	Value.	Value per ton.	Short tons.	Value.	Value per ton.
1899....	28,221	$725,944	$25.90	5,343	$366,598	$68.61
1900....	42,062	1,134,663	26.98	5,656	496,380	87.76
1901....	44,146	1,167,684	26.45	4,561	393,259	86.22
1902....	55,733	1,449,104	26.00	5,358	433,722	80.93
1903....	39,411	987,000	25.04	7,215	578,215	80.14
1904....	35,911	905,782	25.22	8,157	628,494	77.05
1905....	30,946	848,451	27.41	11,280	810,203	71.83
1906....	27,720	733,300	26.45	15,578	1,149,297	73.78
1907....	20,352	579,490	28.47	13,256	1,069,924	80.71
1908....	26,108	877,745	33.60	12,008	845,070	70.37
1909....	12,456	412,300	33.10	14,846	1,026,377	69.14
1910....	19,711	649,425	32.95	13,166	943,968	71.69
1911....	18,281	642,884	44.12	14,618	1,051,311	71.92
1912....	23,349	823,997	35.30	17,064	1,247,702	73.12
1913....	17,712	631,991	35.68	14,466	1,136,257	78.55

(a) In addition to the exports of ore, 15,887 short tons of zinc dross (galvanizers' waste) were exported in 1906, 9593 short tons in 1907, 8405 short tons in 1908, 7069 short tons in 1909, 4728 short tons in 1910, 4246 tons in 1911, 205 tons in 1912, and 28 tons in 1913.

EXPORTS OF DOMESTIC SPELTER FROM THE UNITED STATES. (a)

Year.	Plates, Sheets, Pigs and Bars.		Wares.	Total Value.
	Short Tons.	Value.	Value.	
1898	10,499	$1,033,959	$138,165	$1,724,188
1899	6,755	742,521	143,232	1,978,295
1900	22,411	2,217,963	99,288	2,317,251
1901	3,390	228,906	82,046	310,952
1902	3,237	300,557	114,197	414,754
1903	1,521	163,379	71,354	234,733
1904	10,073	1,094,490	117,957	1,212,447
1905	5,516	682,254	159,995	842,249
1906	4,670	583,526	204,269	787,795
1907	563	75,526	186,283	261,397
1908	2,640	250,254	88,485	338,739
1909	2,566	263,010	69,751	332,761
1910	3,990	426,560	101,336	527,896
1911	6,872	810,099	134,518	944,617
1912	6,634	864,292	140,027	1,004,319
1913	7,782	955,667	145,984	1,101,651

(a) There is also a comparatively insignificant re-export of foreign-made spelter and zinc wares.

IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES.
(In pounds.)

Year.	Sheets, Blocks, Pigs and Old.		Manufactures.	Total Value.	Oxide.	
	Amount.	Value.			Dry.	In Oil.
1898..	2,742,357	$109,624	$13,448	$123,072	3,342,235	27,050
1899..	2,985,463	151,956	14,800	166,756	3,012,709	41,699
1900..	2,013,196	97,772	36,836	134,608	2,618,808	38,706
1901..	775,881	30,920	42,643	73,563	3,199,778	128,198
1902..	1,238,091	46,713	37,191	83,904	3,271,385	163,081
1903..	728,614	30,900	18,938	49,838	3,487,042	166,034
1904..	933,474	44,326	11,918	56,244	2,585,661	224,244
1905..	1,042,081	51,052	12,390	63,442	3,436,367	342,944
1906..	4,407,481	253,310	17,385	270,695	4,191,476	292,538
1907..	3,555,890	210,322	16,282	226,604	5,311,318	362,418
1908..	1,762,627	85,885	7,474	93,359	4,635,101	210,166
1909..	19,340,029	826,588	19,176	845,764	6,119,328	535,024
1910..	6,904,389	289,689	27,475	317,164	6,133,840	336,257
1911..	3,275,340	170,634	124,983	295,617	(a)5,561,016	.....
1912..	22,229,831	1,280,426	293,089	1,573,515	(a)5,875,057	.....
1913..	12,199,267	660,706	62,256	(b) 722,962	6,580,944	284,150

(a) Both dry and in oil.
(b) Zinc dust to the amount of 4,382,470 lb., valued at $227,585, was also imported in 1913.

Spelter Statistics for 1913[1]

W. R. Ingalls.—Revised and complete statistics of the zinc industry in the United States show a total production of spelter by ore-smelters in 1913 of 358,262 tons, of which about 8764 tons were derived from galvanizers' dross, skimmings, scrap, etc., and the remainder from ore. The production from dross, scrap, etc., was 7447 tons in 1912, 9030 tons in 1911 and 7793 tons in 1910. These data do not include the production of spelter by concerns which treat dross and scrap only, whose output amounts to about 16,000 tons per annum.

PRODUCTION OF SPELTER IN THE UNITED STATES.
BY ORE SMELTERS.

States.	1905.	1906.	1907.	1908.	1909.	1910.(c)	1911.(c)	1912. (c)	1913.(c)
Colorado	6,599	6,260	5,200	3,079	6,115	6,564	7,477	8,860	8,637
Illinois (a)	45,357	48,238	56,103	50,244	75,229	79,570	88,681	94,902	111,551
Kansas	114,948	129,741	133,561	99,136	103,390	105,697	106,173	111,761	85,157
Missouri	11,800	11,088	11,594	10,196	8,418	6,485			
Oklahoma	.....	.....	5,094	14,867	28,840	34,760	46,333	76,837	83,230
South and East (b)	23,044	30,167	38,060	32,989	44,470	43,989	47,172	56,278	69,687
Total tons of 2000lb.	201,748	225,494	249,612	210,511	266,462	277,065	295,836	348,638	358,262
Total tons of 2240lb.	180,132	201,343	222,868	187,776	237,913	247,364	264,139	311,284	319,875
Total metric tons	183,014	204,548	226,398	190,933	241,730	251,348	268,378	316,368	325,102

(a) Up to 1903, inclusive, includes also the production of Indiana. (b) New Jersey, Pennsylvania and Virginia, and (since 1903) West Virginia. (c) From *Eng. and Min. Journ.*

BY DROSS AND SCRAP SMELTERS

	1910	1911	1912	1913
	11,350	(a) 13,500	(a) 15,000	(a) 16,000
Total Production of Zinc				
	1910	1911	1912	1913
Ore smelters	277,065	295,836	348,638	358,262
Dross smelters (a)	11,350	13,500	15,000	16,000
Totals	288,415	309,336	363,638	374,262

(a) Estimated.

The amount of the recovered spelter that should properly be counted statistically is uncertain.. A good deal of scrap zinc is remelted in the manufacturing plants where it is made, *e.g.*, in every rolling mill, and such remelted zinc should not, of course, appear in any statistical

[1] *Eng. Min. Jour.*

enumeration. On the other hand certain smelters buy and re-distill and subsequently sell as spelter, often of excellent quality, what was distinctly a waste product. This is obviously an addition to the new supply of spelter and should be recognized just as is that which the ore smelters recover from dross, skimmings, etc.

RECEIPTS OF ZINC ORE.

(In tons of 2000 lb. This table includes the receipts of ore by the smelters only and does not include the production of ore exported or what was taken by the manufacturers of zinc oxide.)

State	1910 (a)	1911 (a)	1912 (a)	1913
Arizona	7,568	6,895	11,937	9,347
Arkansas	190	860	1,567	1,500
California	(d)	3,754	6,639	6,796
Colorado	77,065	158,528	212,423	220,166
Idaho	10,248	9,667	19,482	31,835
Kentucky	179	575	947	441
Missouri-Kansas	289,913	268,500	289,177	280,000
Montana	33,514	56,593	34,034	91,257
Nevada	4,915	5,666	20,654	22,313
New Mexico	15,959	10,184	25,889	14,593
Oklahoma	1,640	8,750	4,325	23,500
Tennessee	2,775	3,439	6,635	8,297
Utah	27,318	19,933	24,539	27,073
Wisconsin (b)	51,383	71,565	90,762	89,662
Others	46,905	44,896	56,099	57,241
Totals	569,572	669,305	805,109	884,021
Mexico	29,198	28,596	29,436	19,965
Canada	11,795	2,356	9,707	6,012
Grand totals (c)	610,565	700,257	844,252	909,998

(a) Smelters' receipts: reports missing from three small smelters. (b) Including Illinois and Iowa. (c) In addition to the ore reported from Canada and Mexico, zinc smelters received a few thousand tons from Europe and Eastern Siberia in 1913. (d) Included in "Others."

Of the total spelter production of the ore smelters in 1911, concerns using coal as fuel produced 119,989 tons, or about 40 per cent. of the total. In 1912 they produced 134,077 tons, which was only about 38 per cent. of the total. In 1913, their production as 231,346, or about 60 per cent. of the total.

In addition to the spelter production there was an output of 423 tons of commercial zinc dust in 1913, against 492 tons in 1912 and 254 tons in 1911. Two smelters are engaged in this business. The importations of zinc dust were about 2200 tons, against 2400 tons in 1912 and 1713 tons in 1911.

In 1910 there were produced 3398 tons of spelter in bond. In 1911 the production in this way was 9598 tons, in 1912 it was 10,879 tons, and in 1913, it was 5904 tons. The exports of bonded spelter are stated in an accompanying table.

SPELTER PRODUCTION IN 1913 BY QUARTERS.
(Reports of Ore Smelters Only.)
(In tons of 2000 lb.)

District.	I.	II.	III.	IV.
Illinois	27,924	28,523	26,118	28,986
Kansas-Missouri	22,006	23,820	19,204	20,127
Oklahoma	21,430	21,840	18,502	21,458
Others (a)	20,722	20,153	19,238	18,211
Totals	92,082	94,336	83,062	88,782

(a) With the exception of one plant in Colorado these are all Eastern works.

There was a large increase in zinc-ore production in 1913, which in part was due, no doubt, to the stimulus of the high prices prevailing in the early part of the year, but even allowing for that, the increase was so large that it must cause a reconsideration of previously held ideas respecting a shortage of zinc ore. There was a large increase in the output of Butte, Mont., where milling difficulties were solved. Idaho and Oklahoma exhibited noteworthy gains. In Tennessee, where an important new mine was developed, there was only a small gain. Rather surprising was the falling off in New Mexico, where the successful milling of the Magdalena ore was supposed to have become an accomplished fact. Joplin, Leadville and the Wisconsin districts about held their own.

The statistics of zinc-ore production are based in the main upon reports from various smelters respecting the quantity of ore received by them and its origin. There are some discrepancies between the figures thus compiled and figures reported in other ways. Thus, the production of the Butte & Superior Co. was reported at about 103,000 tons, while the smelters reported receiving only 91,257 tons from Montana. Mr. Kennedy's figures for Wisconsin showed a great falling off in output in that state in 1913, but the smelters' figures show about the same total of ore received in 1913 as in the previous year.

In 1913, there were eight zinc smelters who produced sulphuric acid from blende, the Robert Lanyon Zinc & Acid Co. being an addition to the list. The statistics of the works of this class for the last 3 years are as follows:

STATISTICS OF SPELTER-SULPHURIC ACID WORKS.
(In tons of 2000 lb.)

	1910.	1911.	1912.	1913.
Ore received	.....	.....	287,205	364,741
Spelter produced	100,791	115,310	127,655	148,188
Sulphuric acid produced, basis 60°	202,000	252,192	262,555	305,167

As in the previous year the smelters who make sulphuric acid drew their main ore supply from the Joplin district and Wisconsin, but it is noteworthy that some of these smelters now use a good deal of Western ore. In 1911 they received 107,995 tons of blende from the Joplin district and 71,168 tons from Wisconsin. In 1912 they obtained 117,806 tons from Joplin and 87,676 tons from Wisconsin. In 1913 they obtained 159,540 tons from the Joplin district and 84,495 tons from the Wisconsin district. Oklahoma and Kansas are reckoned with the Joplin district.

The total stock of spelter at smelters' works at the end of 1913 was 40,115 tons, against 4264 at the end of 1912, 9323 at the end of 1911 and 23,000 tons at the end of 1910. The deliveries into consumption are computed in the accompanying table.

DELIVERIES INTO CONSUMPTION.

	1910.	1911.	1912.	1913.
Stock, Jan. 1	11,500	23,000	9,323	4,264
Production	288,415	309,336	363,638	374,262
Imports	3,452	1,637	11,115	6,100
Totals	303,367	333,973	384,076	384,626
Exports, domestic	3,989	6,872	6,634	7,782
Exports, foreign	4,468	11,270	8,700	.....
Stock, Dec. 31	23,000	9,323	4,264	40,115
Deliveries	271,892	316,508	364,488	.....

The stock of spelter at the end of 1913 was the largest of which we have record. Deliveries are computed by difference between (*a*) stocks, plus production, plus imports, and (*b*) exports plus stocks, but the experiences of 1912–13 show how futile it is to attempt to compute consumption in that way, and how important a part is played by the stocks in the yards of galvanizers and brass makers, the invisible supply. At the end of 1912 that invisible supply was large, no doubt; at the end of 1913 it was believed to be small. However, that was only surmise and the subsequent history of the market throws doubt upon it. Included in the stock reported at the end of 1913 was 615 tons of bonded spelter.

Another point that deserves note is the increasing production of spelter from dross and the decreasing exports of that material. In 1911 the exportation was 4246 tons; in 1912 it was 205 tons; and in 1913 it was only 28 tons. We estimate the product redistilled from dross, skimmings, etc. (by works treating this material only) at 13,500 tons in 1911, 15,000 tons in 1912, and 16,000 tons in 1913, and probably these figures are underestimates rather than overestimates. In taking a statistical view, this spelter must be added to the spelter obtained otherwise, it being sold in the same way and being just as good, and indeed often better than some of the virgin spelter.

The following tables compiled by C. E. Siebenthal and published by the United States Geological Survey, are as authentic as can be obtained, and give the production of primary and secondary spelter in United States, World's production of spelter, consumption of primary spelter in United States, as well as exports and imports of zinc ore.

PRODUCTION OF SPELTER IN 1913.
(In tons of 2000 lb.)

	1912.	1913.	Change in 1913.	
			Quantity.	Percentage.
Production of primary spelter in the United States	338,806	346,676	+ 7,870	2.3
Consumption of primary spelter in the United States	340,341	295,370	− 44,971	13.2
Production of spelter in the world	1,070,045	1,103,359	+ 33,314	3.1

PRODUCTION OF PRIMARY SPELTER[1] IN THE UNITED STATES, 1908–1913.
(In Tons of 2000 lb.)
[1] Apportioned According to Source of Ore.

	1908.	1909.	1910.	1911.	1912.	1913.
UNITED STATES:						
Arizona	152	2,862	2,594	2,336	4,092	3,152
Arkansas	2,002	135	286	385	604	478
California	27	.....	.....	1,099	1,672	2,535
Colorado	24,885	20,121	23,238	42,233	60,841	58,113
Idaho	581	901	3,454	3,180	6,800	10,190
Illinois	298	675	1,551	2,884	3,952	1,345
Iowa	516	.....	40	.....	.....	.....
Kansas	8,628	9,185	10,220	6,843	5,668	9,986
Kentucky	341	22	29	205	394	172
Maine	.....	.....	.....	.....	.....	.....
Missouri	123,655	140,676	140,652	127,540	149,557	129,018
Montana	900	4,725	12,408	22,115	14,196	35,756
Nevada	398	825	1,516	1,595	6,132	5,828
New Jersey	6,926	16,035	20,217	15,128	16,941	24,247
New Mexico	134	3,961	4,911	3,778	6,882	3,765
Oklahoma	2,235	3,008	2,397	2,247	2,041	6,397
Tennessee	341	695	925	1,000	1,935	2,625
Texas	.....	.....	.....	.....	245	303
Utah	282	5,960	7,221	7,004	7,756	9,503
Virginia	910	58	1,168	228	62	116
Washington	.....	.....	.....	12	.....	.....
Wisconsin	17,538	20,381	19,752	31,809	34,137	33,743
Total domestic	190,749	230,225	252,479	271,621	323,907	337,252
FOREIGN:						
Canada	2,425	978	3,304	1,598	4,199	1,424
Mexico	17,250	24,557	13,401	13,307	10,700	6,205
Europe	.....	.....	.....	.....	.....	1,175
Sibera	.....	.....	.....	.....	.....	620
Total foreign	19,675	25,535	16,705	14,905	14,899	9,424
Grand total	210,424	255,760	269,184	286,526	338,806	346,676
Apportioned According to Locality in which Smelted.						
Illinois	50,244	67,653	73,038	83,130	88,397	106,654
Kansas	99,298	103,299	105,697	98,413	101,104	74,106
Oklahoma	14,864	28,782	34,760	46,315	76,925	83,214
Other States	46,018	56,026	55,689	58,668	72,380	82,702
Total	210,424	255,760	269,184	286,526	338,806	346,676

PRODUCTION OF SECONDARY ZINC IN THE UNITED STATES, 1908–1913.

Secondary spelter, redistilled.	7,159	9,273	12,784	14,043	26,064	[2]26,491
Secondary spelter, remelted..	9,811	23,767	28,439	26,470	26,187	[2]23,000
Recovered zinc in alloys, excluding old brass remelted..	665	1,181	2,709	3,223	3,912	[2]3,600

[1] Primary spelter is made directly from ore, but secondary spelter is recovered from such sources as drosses, skimmings, and old metals.
[2] Subject to final revision.

WORLD'S PRODUCTION OF SPELTER 1908–1913.

	1908.	1909.	1910.	1911.	1912.	[1]1913.
Locality in which smelted:						
Australia	1,198	.....	560	1,904	2,531	4,105
Austria and Italy	14,063	13,931	14,666	18,602	21,609	23,856
Belgium	181,851	184,194	190,233	215,050	220,678	217,941
France and Spain	61,512	61,859	65,191	70,791	79,543	78,293
Germany	239,062	242,594	251,046	276,008	298,794	311,914
Great Britian	60,029	65,422	69,531	73,803	63,086	65,201
Holland	19,017	21,548	23,121	25,059	26,380	26,813
Norway	.....	.....	.....	7,363	8,959	19,040
Poland	9,740	8,758	9,514	10,952	9,659	9,520
United States	210,424	255,760	269,184	286,526	338,806	346,676
Total	796,896	854,066	893,046	986,061	1,070,045	1,103,359
United States percentage of world's production	26.4	29.9	30.1	29.1	31.7	31.4

[1] Subject to final revision.

CONSUMPTION OF PRIMARY SPELTER IN THE UNITED STATES, 1908–1913.

	1908.	1909.	1910.	1911.	1912.	1913.
Supply:						
Stock, Jan. 1—						
In bonded warehouses...	2	9	39	31	32	48
At smelters	26,364	19,613	11,167	23,201	9,049	4,474
Production—						
From domestic ore	190,749	230,225	252,479	271,621	323,907	337,252
From foreign ore	19,675	25,535	16,705	14,905	14,899	9,424
Imports	881	9,454	1,960	609	11,115	6,100
Total available	237,671	284,836	282,350	310,367	359,002	357,298
Withdrawn:						
Exports, foreign, from warehouse	8	334	4,758	11,276	6,286	6,027
Exports, foreign, under drawback	1,234	.....	4,486	3,079	1,188	7,459
Exports, domestic	2,640	2,566	3,990	6,872	6,634	7,783
Stock, Dec. 31—						
In bonded warehouses...	9	39	31	32	48	.....
At smelters	19,613	11,167	23,201	9,049	4,474	40,659
Total withdrawn	23,504	14,106	36,466	30,308	18,383	61,928
Apparent consumption	214,167	270,730	245,884	280,059	340,372	295,370

NOTE.—Imports and exports of spelter are given under the heading "Consumption." The imports of spelter in 1909–1913 are as given in the December Summary of the Bureau of Foreign and Domestic Commerce except that for 1909–1912 inclusive the quantities given therein have been diminished by the quantity of zinc dust imported since Aug. 6, 1909, for the reason that the imports of spelter and zinc dust were not separated in the Summary. The imports of spelter are also exclusive of sheet zinc. The stock in bonded warehouses does not include zinc ore in bond or the spelter made thereform, such spelter being included in stock at smelters.

The following tables compiled by C. E. Siebenthal and published by the United States Geological Survey, are as authentic as can be obtained, and give the production of primary and secondary spelter in United States, World's production of spelter, consumption of primary spelter in United States, as well as exports and imports of zinc ore.

PRODUCTION OF SPELTER IN 1913.
(In tons of 2000 lb.)

	1912.	1913.	Change in 1913.	
			Quantity.	Percentage.
Production of primary spelter in the United States	338,806	346,676	+ 7,870	2.3
Consumption of primary spelter in the United States	340,341	295,370	− 44,971	13.2
Production of spelter in the world	1,070,045	1,103,359	+ 33,314	3.1

PRODUCTION OF PRIMARY SPELTER[1] IN THE UNITED STATES, 1908–1913.
(In Tons of 2000 lb.)

[1] Apportioned According to Source of Ore.

	1908.	1909.	1910.	1911.	1912.	1913.
UNITED STATES:						
Arizona	152	2,862	2,594	2,336	4,092	3,152
Arkansas	2,002	135	286	385	604	478
California	27	.....	.....	1,099	1,672	2,535
Colorado	24,885	20,121	23,238	42,233	60,841	58,113
Idaho	581	901	3,454	3,180	6,800	10,190
Illinois	298	675	1,551	2,884	3,952	1,345
Iowa	516	.....	40	.....	.....	.....
Kansas	8,628	9,185	10,220	6,843	5,668	9,956
Kentucky	341	22	29	205	394	172
Maine	.....	.....	.....	.....	.....	.....
Missouri	123,655	140,676	140,652	127,540	149,557	129,018
Montana	900	4,725	12,408	22,115	14,196	35,756
Nevada	398	825	1,516	1,595	6,132	5,828
New Jersey	6,926	16,035	20,217	15,128	16,941	24,247
New Mexico	134	3,961	4,911	3,778	6,882	3,765
Oklahoma	2,235	3,008	2,297	2,247	2,041	6,397
Tennessee	341	695	925	1,000	1,935	2,635
Texas	.....	.....	.....	.....	245	303
Utah	282	5,960	7,221	7,004	7,756	9,503
Virginia	910	58	1,168	228	62	116
Washington	.....	.....	.....	12	.....	.....
Wisconsin	17,538	20,381	19,752	31,809	34,137	33,743
Total domestic	190,749	230,225	252,479	271,621	323,907	337,252
FOREIGN:						
Canada	2,425	978	3,304	1,598	4,199	1,424
Mexico	17,250	24,557	13,401	13,307	10,700	6,205
Europe	.....	.....	.....	.....	.....	1,175
Sibera	.....	.....	.....	.....	.....	620
Total foreign	19,675	25,535	16,705	14,905	14,899	9,424
Grand total	210,424	255,760	269,184	286,526	338,806	346,676
Apportioned According to Locality in which Smelted.						
Illinois	50,244	67,653	73,038	83,130	88,397	106,654
Kansas	99,298	103,299	105,697	98,413	101,104	74,106
Oklahoma	14,864	28,782	34,760	46,315	76,925	83,214
Other States	46,018	56,026	55,689	58,668	72,380	82,702
Total	210,424	255,760	269,184	286,526	338,806	346,676

ZINC SMELTING CAPACITY OF THE UNITED STATES.

(Number of Retorts at End of Years.)

Name.	Location.	1912.	1913.
American Zinc, Lead & Smelting Co	Hillsboro, Ill	1,600	3,200
American Zinc, Lead & Smelting Co	Deering, Kan	3,840	3,840
American Zinc, Lead & Smelting Co	Caney, Kan	3,648	3,648
Bartlesville Zinc Co	Bartlesville, Okla	5,184	5,184
Bartlesville Zinc Co	Collinsville, Okla	8,064	8,064
Chanute Zinc Co	Chanute, Kan	1,280	1,280
Clarksburg Zinc Co	Clarksburg, W. Va	.....	2,736
Beer, Sondheimer & Co	Altoona, Kan	3,300	(d) 3,960
L. Vogelstein & Co	Gas City, Kan	(a) 2,560	(e) 2,520
L. Vogelstein & Co	La Harpe, Kan	640	(f) 1,856
Collinsville Zinc Co	Collinsville, Ill	1,536	1,536
Edgar Zinc Co	St. Louis, Mo	2,000	2,000
Edgar Zinc Co	Cherryvale, Kan	4,800	4,800
Granby Mining & Smelting Co	Neodesha, Kan	3,840	3,760
Grasselli Chemical Co	Clarksburg, W. Va	12,672	12,672
Grasselli Chemical Co	Meadowbrook, W. Va		
Hegeler Bros	Danville, Ill	1,800	1,800
Illinois Zinc Co	Peru, Ill	4,640	4,640
Lanyon-Starr Smelting Co	Bartlesville, Okla	3,456	3,456
Lanyon Zinc & Acid Co	Hillsboro, Ill	.....	1,840
Matthiessen & Hegeler	Lasalle, Ill	5,256	5,256
Mineral Point Zinc Co	Depue, Ill	4,520	6,800
National Zinc Co	Bartlesville, Okla	4,256	4,480
Nevada Zinc Co	Nevada, Mo	(b) 648	672
New Jersey Zinc Co	Palmerton, Penn	5,772	5,760
Pittsburg Zinc Co	Pittsburg, Kan	910	910
Prime Western Spelter Co	Gas City, Kan	4,834	4,768
Sandoval Zinc Co	Sandoval, Ill	896	996
Tulsa Fuel and Manufacturing Co	Collinsville, Okla	6,232	6,232
United States Zinc Co	Pueblo, Colo	1,920	1,920
United Zinc and Chemical Co	Springfield, Ill	3,200	3,200
Total		103,304	113,786

(a) Inactive. (b) Inactive during latter part of year. (c) (d) Now Altoona Zinc Smelting Co. (e) Kansas Zinc Co. (f) La Harpe Spelter Co.

ADDITIONAL RETORTS BUILDING IN 1914.*

American Zinc Co. of Illinois	800
Granby M. & S. Co	3,240
Hegeler Bros	1,800
Matthiessen & Hegeler Zinc Co	912
Mineral Point Zinc Co	2,280
American Zinc & Acid Co	3,456
Total	12,488

The following table taken from the *Mining & Engineering World*, shows the production of spelter from both domestic and foreign ores, apportioned according to the states in which it was smelted, by 6-month periods:

PRODUCTION OF SPELTER FROM DOMESTIC AND FOREIGN ORES.

State.	1912. First half.	1912. Second half.	1913. First half.	1913. Second half.
Illinois	44,224	44,065	53,524	52,424
Kansas	52,485	43,376	42,645	33,846
Oklahoma	36,010	41,584	43,253	39,755
Other states	33,777	38,109	40,791	39,337
Total	166,496	172,134	180,213	165,362
Yearly total	338,630		345,575	

* From the report upon spelter production in 1913 by C. E. Siebenthal of the U. S. Geological Survey.

As shown in the above table, the output for all the states was less in the second half of the year, Kansas and Oklahoma having the greatest loss. At the beginning of the year, about 101,000 retorts were available, and 5850 more were added during the year, giving for the plants which were active during the year a total of about 107,000. The following table from *Mining & Engineering World* gives the capacity of the smelters by states, together with additions planned for 1914, and the average number of retorts in active operation during December, 1913.

CAPACITY OF ZINC SMELTERS.

State.	Total retorts end of 1913.	Retorts to be added in 1914.	Average number of retorts operated in December, 1913.
Illinois	29,268	9,032	27,067
Kansas	33,862	.....	15,896
Oklahoma	27,416	.....	23,024
Other states	25,760	3,456	23,696
Total	116,306	12,488	89,683

From the above it is seen that only three-fourths of the total smelting capacity was operated during December. In Kansas one-half of the retorts were idle, and in Oklahoma about one-sixth. Because of unfavorable conditions construction work by plants planning additions has not been rushed. Hegeler Bros. will not start operating their new retorts until the middle of 1914. Of the 4560 retorts to be added in 1913 to the Mineral Point smelter at Depue, Ill., only 2280 were actually constructed and 2280 will be added some time in 1914. No new retorts are planned in Kansas or Oklahoma for 1914. The construction work on the smelter of the American Zinc and Chemical Co., at Langeloth, Pa., is being pushed, and it is hoped to have it operating some time in the summer. It is planned to enlarge this plant as necessitated by the closing down of affiliated plants in Oklahoma, due to failure of natural gas there. The Prime Western Spelter Co. is constructing zinc roasting furnaces and an acid plant at Tiltonville, Ohio.

The Spelter Market in 1913

Spelter opened at St. Louis in January at 7.17 cents a pound, which was the maximum price for the year. From this price the decline was rapid, until by the middle of June the low mark of the year was reached at 4.974 cents. A slight rise brought the price to 5.85 cents by the latter part of August, but this rally was short lived, and at the close of the year spelter at St. Louis was quoted at about 5 cents.

There were many causes contributing to bring about the rapid decline from the high prices prevailing at the beginning of the year. It will readily be admitted that a price above 7 cents is high, for experience and observation have shown that about 5 1/2 cents at St. Louis is the normal

price. Among the more prominent factors responsible for the drop in price are the heavy buying of spelter during the latter part of 1912 in anticipation of smelter difficulties due to natural gas shortage which failed to materialize; the greatly stimulated production of ore; the importation of spelter from Europe; the anticipation of a 10 per cent. advalorem duty on spelter and spelter in ores—later raised to 15 per cent. on spelter; and the damage done to the galvanizing business by the heavy floods which devastated the middle west.

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN ST. LOUIS.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1904....	4.673	4.717	4.841	5.038	4.853	4.596	4.723	4.716	4.896	5.033	5.363	5.720	4.931
1905....	6.032	5.989	5.917	5.667	5.284	5.040	5.247	5.556	5.737	5.934	5.984	6.374	5.730
1906....	6.337	5.924	6.056	5.931	5.846	5.948	5.856	5.878	6.056	6.070	6.225	6.443	6.048
1907....	6.582	6.664	6.687	6.535	6.291	6.269	5.922	5.551	5.086	5.280	4.775	4.104	5.812
1908....	4.363	4.638	4.527	4.495	4.458	4.393	4.338	4.556	4.619	4.651	4.909	4.987	4.578
1909....	4.991	4.739	4.607	4.815	4.974	5.252	5.252	5.579	5.646	6.043	6.231	6.099	5.352
1910(a)	5.951	5.419	5.487	5.289	5.041	4.978	5.002	5.129	5.364	5.478	5.826	5.474	5.370
1911(a)	5.302	5.368	5.413	5.249	5.108	5.370	5.545	5.803	5.719	5.951	6.223	6.151	5.608
1912(a)	6.292	6.349	6.476	6.483	6.529	6.727	6.966	6.878	7.313	7.276	7.221	7.081	6.799
1913(a)	6.854	6.089	5.926	5.491	5.256	4.974	5.128	5.508	5.554	5.188	5.083	5.004	5.504

(a) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1901....	4.13	4.01	3.91	3.98	4.04	3.99	3.95	3.99	4.08	4.23	4.29	4.31	4.07
1902....	4.27	4.15	4.28	4.37	4.47	4.96	5.27	5.44	5.49	5.38	5.18	4.78	4.84
1903....	4.87	5.04	5.35	5.55	5.63	5.70	5.66	5.73	5.69	5.51	5.39	4.73	5.40
1904....	4.863	4.916	5.057	5.219	5.031	4.760	4.873	4.866	5.046	5.181	5.513	5.872	5.100
1905....	6.190	6.139	6.067	5.817	5.434	5.190	5.396	5.706	5.887	6.087	6.145	6.522	5.882
1906....	6.487	6.075	6.209	6.078	5.997	6.096	6.006	6.027	6.216	6.222	6.375	6.593	6.198
1907....	6.732	6.814	6.837	6.685	6.441	6.419	6.072	5.701	5.236	5.430	4.925	4.254	5.962
1908....	4.518	4.788	4.665	4.645	4.608	4.543	4.485	4.702	4.769	4.801	5.059	5.137	4.726
1909....	5.141	4.889	4.757	4.965	5.124	5.402	5.402	5.729	5.796	6.199	6.381	6.249	5.503
1910(a)	6.101	5.569	5.637	5.439	5.191	5.128	5.152	5.279	5.514	5.628	5.976	5.624	5.520
1911(a)	5.452	5.518	5.563	5.399	5.348	5.520	5.695	5.953	5.869	6.102	6.380	6.301	5.758
1912(a)	6.442	6.499	6.626	6.633	6.679	6.877	7.116	7.028	7.464	7.426	7.371	7.162	6.943
1913(a)	6.931	6.239	6.078	5.641	5.406	5.124	5.278	5.658	5.694	5.340	5.229	5.154	5.648

(a) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF SPELTER IN LONDON.
(Pounds sterling per ton of 2240 lb. of good ordinary brands.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.
1906....	28.225	25.844	24.563	25.781	27.000	27.728	26.800	26.938	27.563	28.075	27.787	27.938	27.020
1907....	27.125	25.938	26.094	25.900	25.563	25.469	23.850	21.969	21.050	21.781	21.438	20.075	23.771
1908....	20.563	20.875	21.075	21.344	19.906	19.000	19.031	19.350	19.563	19.750	20.875	20.625	20.163
1909....	21.425	21.563	21.438	21.531	21.975	22.000	21.969	22.125	22.906	23.200	23.188	23.094	22.185
1910(a).	23.350	23.188	23.031	22.469	22.100	22.094	22.406	22.800	23.165	23.900	24.083	24.019	23.050
1911(a).	23.887	23.276	23.016	23.743	24.375	24.612	25.006	26.801	27.750	27.256	26.795	26.849	25.281
1912(a).	26.642	26.661	26.048	25.644	25.790	25.763	26.174	26.443	27.048	27.543	26.804	26.494	26.421
1913(a)	26.114	25.338	24.605	25.313	24.583	22.143	20.592	20.706	21.148	20.614	20.581	21.214	22.746

(a) From *Eng. Min. Jour.*

The European zinc convention was renewed on Dec. 18, 1913, for a period running to April 1, 1916. The new terms are about the same as the old ones, but restriction of production is made a little more prompt. Under the old terms curtailment began after the price had ruled below £22 for four consecutive months, the unsold stocks being in excess of 50,000 tons. The new terms require that the price run below £22 for only two months.

The Tariff.—It is somewhat early yet to predict just what effect the change in tariff will have on the zinc industry in this country, but it would seem that under normal conditions in this country and in Mexico, the new rates would work to the advantage of the smelter, and to the disadvantage of the ore producer. While mining in Mexico is in such a deplorable condition, the competition from that source cannot become a serious problem, but when political conditions there become stable undoubtedly a great increase of ore importations will take place.

A comparison of the old Payne-Aldrich tariff and the new tariff as regards the zinc industry, is made in the following table.

	Payne-Aldrich	New Tariff
Zinc ores, including calamine, containing less 10 per cent. zinc...	free	*10 per cent.
containing 10 per cent. or more, and less 20 per cent.....	¼c lb on zinc	*10 per cent.
containing 20 per cent. or more, less 25 per cent.....	⅓c lb on zinc	*10 per cent.
containing 25 per cent. or more.....	1c lb on zinc	*10 per cent.
blocks, pigs, or dust.....	1⅜c lb	15 per cent.
sheets.....	1⅝c lb	15 per cent.
worn out, fit only to remanufacture	1c lb	15 per cent.

Zinc Mining in the United States

Arizona.—The production of zinc ores in 1913 was 3152 short tons, a loss of nearly 1000 tons over 1912. This loss was largely due to the shutting down during part of the year of the Golconda mine, formerly the largest zinc producer. The San Xavier mine, in Pima County, shipped a large quantity of ore, and much zinc concentrate was recovered from Mohave County ores in the concentrator at Needles.

Arkansas.—The zinc output of Arkansas amounted to 478 tons of spelter, derived about equally from blende and carbonate ores, a decrease of about 36 per cent. from the figures for 1912. The zinc-ore deposits near Zinc, a station on the White river division of the Missouri Pacific railroad in northern Arkansas, continue to attract considerable attention, and their genesis seems to be similar to that of the Missouri and Wisconsin deposits.

California.—The gain in spelter produced in California amounted to nearly 50 per cent. over 1912, the figure for 1913, according to U. S. Geological Survey, being 2535 short tons. Most of the zinc was obtained from the old Cerro Gordo mines, in Inyo County, formerly worked for silver-lead ores.

Colorado.—The production of spelter for 1913 was 58,113 tons, a slight falling off from the figure of 60,841 tons for 1912. The Leadville district yielded about 75 per cent. of the total production, the output of carbonate ores being 137,000 tons of about 27 per cent. average zinc content. Considerable impetus has already been given to the mining of carbonate ores in Colorado, especially at Leadville, by the attitude of the smelters of Kansas and Oklahoma. Early in the year they announced that they would accept as low as 18 per cent. zinc ore from the mines at Leadville. This means that many bodies of zinc ore, too low grade to be handled in the past, will now be placed on the market. In a large number of mines there are bodies of this grade of ore, and active work will doubtless result in increasing the output for next year. For a long time, owing to the increasing cost of natural gas in Kansas and Oklahoma, the smelters have looked with favor on the carbonate ores, on account of the saving in roasting expense, and they have previously accepted as low as 25 per cent., and this recent acceptance of 18 per cent. ore shows the increasing favor with which the smelters regard carbonate ores. The most important deposits of this ore at Leadville are situated on the northern side of Carbonate Hill and are in the Maid of Erin, Henriette, Clontarf, Brookland, Monte Cristo, Wolftone, Waterloo, Morning Star, and Big Chief mines. The first six of these are under lease to, and are worked by the Western Mining Co., a Guggenheim concern; and all the others are worked through the Wolftone Shaft of the Western Mining Co.

Apart from Leadville, the Aspen, Creede, San Juan and Rico districts are capable of making good productions of lead and zinc, usually both together. At some plants the roasting and magnetic treatment is being used, while others find the electrostatic methods of separation to give the better results. The costs of the two methods are likely about the same, the expense of roasting being offset by the royalties charged by the owners of the electrostatic patents.

Idaho.—The zinc output of Idaho showed a large gain over the previous year, the figures for 1913 being 10,190 tons, as against 6800 tons in 1912. The heavy zinc output was largely due to the operations of the Success, Morning, Green-Hill-Cleveland, Interstate-Callahan, and Hercules mines of the Coeur d'Alene district, the first two mentioned being the largest producers.

Illinois.—The zinc production of this state showed a marked falling off for the year, the figure given by the United States Geological Survey being but 1345, compared to 3952 tons for 1912. The entire output came from the Galena district, in the northwestern part of the state. The Vinegar Hill mine, the Northwestern Zinc Co., the Mineral Point Zinc Co., the Federal mine and the Black Jack all produced during the

year. From the latter two, greatly increased production may be expected for the coming year, as work so far has been confined mostly to developing large bodies of ore. The New Jersey Zinc Co. bought the Black Jack property last June, paying it is reported, $250,000, and have since brought the cost of the investment to $360,000 by improvements and buildings. While shipments up to the end of the year had been light, the large mineralized areas opened up forecast a heavy output of ore for 1914. The Joplin Separating Works was closed down during most of the year, owing to heavy competition.

Kansas.—All of the mining for lead and zinc in this state was done in Cherokee County. Lawton is a camp which has now reached a stage of assured importance, the example set by the Eastern Lead & Zinc Co. having been followed by four other concerns who have erected mills, and production will probably be greatly increased for 1914. Preparations are under way to provide drainage for the old Badger camp, south of Lawton. Drilling will be undertaken this coming year to ascertain whether or not the Miami ore run extends over the line into Kansas. The old Galena camp showed a decline in output and activity. The United States Geological Survey credits Kansas with an output of 10,190 tons of zinc for 1913.

Kentucky.—In the western Kentucky fluorspar district the output of zinc concentrates was only about one-half that of 1912, and as a result the state is credited with only 172 tons of zinc, compared with 394 tons the previous year.

Missouri, Joplin District.—In the Joplin district, as estimated from the weekly ore sales, there was a decrease in the production of blende concentrates and gains in the output of silicate concentrates. The output of blende concentrates is estimated at about 277,000 tons, the silicate concentrates at 19,600 tons, and the recoverable zinc content of the zinc concentrates is estimated at 150,774 tons, a decrease of 1691 tons from the previous year. The zinc concentrate sales of the district fell away sharply in the early part of the year, being but a little over 4000 tons weekly during March. In April the sale increased and during the remainder of the year averaged about 5500 tons weekly. The principal developments of the year were the extension of mining operations in the territory north and west of Joplin in Missouri, about Lawton and Badger, Kans., and north of Miami, Oklahoma.

Numerous changes were made in mine location during 1913; the poorer of the sheet-ground mines were deserted for areas where the ore can be produced at a less expense. This gave an impetus to the Thoms Station group near Joplin, the only point of increased blende production in Jasper County. Dunweg increased its calamine production over 100 per cent.,

while other localities decreased. Newton County has a decrease of blende at all points, with an increase of calamine at Granby alone. Greene County produced very little of either. Lawrence County fell off in blende production, but Aurora made a 100 per cent. increase in calamine. The most noteworthy gains in the district are shown by camps just over the state line, namely at Miami, Okla., and Cherokee County, Kansas.

For the first time in years a number of mines have been forced to suspend operations because of a water famine. Mines that usually keep one or more large pumps at work steadily went completely dry in the summer, and in some places milling operations were curtailed.

Shallow zinc and lead sulphides were developed in a new camp 4 miles north of Carl Junction, the nearest producing area being at Lehigh, 5 miles to the south. Four miles northwest of Joplin at the Cactus mine good zinc sulphide ore was found below the limestone stratum formerly thought to constitute the bed-rock of the district.

Calamine mining in the Duenweg, Mo., camp was more active than it had been for years. Good finds have been made on several properties at shallow depths, the ore averaging 43 per cent. metallic zinc. The North Webb City sheet ground field showed some curtailment due to low prices, and the inability to mine the thinner ground at a profit. This was true of all the sheet ground mines of the Joplin district, and a net loss from 1912 of 26,000 tons of concentrates is recorded for the year. The latter part of the year especially found inactive many mines which had been operated for considerable time at a loss. This falling off in production by the larger companies was partly balanced by the output of smaller producers, and the number of this class was greatly augmented by the activity in prospecting and operating by men thrown out of work by the low prices prevailing for spelter. It is always characteristic of the Joplin district that a low-price period means a new prospecting activity and the discovery of new mines, especially of the rich soft-ground type. This has resulted in some cases in actually increasing the output of certain districts.

The importance of slime treatment is growing throughout the Joplin district, and to-day the majority of the larger milling plants are equipped with tables. A feature of the sludge treatment that is also gaining in popularity is the dewatering screen of the revolving type. The operators of the mines of the American Zinc, Lead & Smelting Co., at Webb City, Mo. have been experimenting with the treatment of overflow waters from the sludge tanks. In former years the waste product from the first milling went to the dump and the water, carrying in suspension a heavy volume of zinc and lead, went to the sludge ponds. As a result it pays to remill the tailing piles, and clean out and mill the sludge ponds, but the

above is the first instance of recovery from the water after it has already passed through a series of settling tanks.

Increasing appreciation of the work of the State Geological Survey has been shown, and State Geologist Buehler is inaugurating a new line of work, which will necessitate the employment of a man in the field to assist prospectors in developing ore by applying the salient features of the local geological conditions. It is unfortunate that more records are not available of the thousands of drill holes already sunk in the district. Where any record is kept, it is often in a vernacular intelligible only to the man who drilled it. It is hoped that with the awakened interest in the value of geology to the district, more accurate records of drillings may be recorded, as the value of such to the community cannot be overestimated.

In many districts the cessation of work by large companies has resulted in the raising of the water level for the whole district, thus putting on the companies working, an additional burden of pumping.

Coal was opened at a depth of 45 ft. at the Shamrock mine, north of Alba, Mo., the seam reported as being 6 ft. thick, and of good quality. It is being mined mostly for local use, being used for operation of the zinc mines of the neighborhood.

The following extract from the review by Jesse A. Zook of the Joplin district for 1913, as published in the *Engineering & Mining Journal* covers the production, and mining conditions in general, omitting the discussion of lead.

The year opened with high prices for all ores of this district, as it closed in 1912, but the decline of spelter from 7 1/8 cents in the beginning to 5.50 cents in March brought blende from a $56 base per ton of 60 per cent. zinc, and calamine from a base of $32 per ton of 40 per cent. zinc, during the first week of the year, to a $40 base for blende and a $23 base for calamine at the end of March. Prices of blende ranged $40 to $45 base until September, when it reached a $48 base one week, declining to $40 in October, to $38.50 in November, but advancing to $40 again in December. Calamine made little change after April, ranging from $20 to $23 base the balance of the year.

On Dec. 9 a number of producers held a called meeting to talk over the situation. A few were producing at a loss, others breaking even, and others yet making a profit. Unlike meetings of a few years ago there was no bombast and no talk of forcing the smelter to pay higher prices. Conditions are vastly different, and this is realized. The meeting was to discuss the subject from a business point of view, and also from a charitable point of view. The question of quitting and leaving the miners without employment in the midst of winter, with nothing to look forward to, was discussed quite as much as the losses sustained. It was

found necessary to make a cut in wages and it was partially agreed that rather than cease operations entirely they would be continued on a limited scale, provided the miners were willing to accept a reduction in wage scale that would make it possible to produce ore without a serious loss, holding on and hoping for an early improvement of conditions.

ORE PRICES IN JOPLIN DISTRICT.

(13 Years.)

Year.	Zinc Ore.		Lead Ore.	
	High.	Aver.	High.	Aver.
1901	$34.00	$24.21	$47.50	$45.99
1902	42.00	30.33	50.00	46.10
1903	42.00	33.72	60.50	54.12
1904	53.00	35.92	62.00	54.80
1905	60.00	44.88	80.00	62.12
1906	54.00	43.30	87.00	77.78
1907	53.50	43.68	88.50	68.90
1908	47.00	34.36	66.00	54.66
1909	55.00	41.08	60.50	54.56
1910	52.00	40.42	58.00	51.98
1911	51.00	39.90	64.00	56.76
1912	67.00	52.15	68.00	56.60
1913	53.16	42.62	57.78	52.82

The plan of contracting blende on any schedule has met with so little favor that it is no longer a feature of serious consideration. Last year's procedure of buying ore on contract and re-selling for a margin of profit on the open market brought this plan into disrepute.

During the summer there was introduced a method of buying blende, carrying over 6 per cent. of iron, on what is termed a "metal base." In substance there is no penalty on the iron content, differing from the "assay base" which recognizes a reduction of $1 per ton of concentrates for each 1 per cent. of iron in excess of 1 per cent. Observing the metal base places settlements on the exact zinc content indicated by assayed samples. The assay base permits a deduction for the iron content and lowers the price of the zinc content for each unit of iron content.

In the manufacture of political capital it is asserted that the existing metal and ore market is the direct result of tariff legislation, no explanation being offered for the preceding European weakness. The Joplin ore market had maintained a plane of prices relatively high, so high that smelters selling spelter have lost money on numerous purchases of ore. There has been no time since the tariff law became effective when it had any bearing on the situation in this district, for the simple reason that Mexican importations have been severely restricted by revolution. Further, there was never a time under the preceding tariff when this district received a permanent benefit, because what restriction was placed on the importation of Mexican ore was more than offset by increased production in the Rocky Mountain region—now producing comparatively a low tonnage. Honesty would place all discrepancies in their proper sphere—demand and supply—but not so with politicians.

JOPLIN DISTRICT ORE SHIPMENTS, IN POUNDS.

	Blende.	Calamine.	Lead.	Values.
Missouri:				
Jasper County	408,645,030	3,673,460	63,439,800	$10,952,815
Newton County	21,938,510	31,095,380	5,028,060	966,881
Greene County	696,650	63,400	.....	18,370
Lawrence County	679,550	4,823,310	272,030	85,930
Total	431,959,740	39,655,550	68,739,890	$12,023,960
Oklahoma:				
Ottawa County	42,929,330	.....	13,560,870	1,138,259
Kansas:				
Cherokee County	37,756,020	15 ,020	5,750,660	1,002,370
Total 11 months	512,645,090	39,806,570	88,051,420	$14,164,625
Estimate of December	40,550,000	3,101,000	6,500,000	1,000,000
Total 1913	553,195,090	42,907,570	94,551,420	$15,164,625
Total 1912	575,483,170	36,679,430	93,589,040	18,703,015
Increase from 1912	.....	6,228,140	962,380	.....
Decrease from 1912	22,288,080	.....	.....	$3,558,390

Monthly Ore Prices.—The accompanying table gives the average prices of lead and zinc ore as determined from actual transactions.

AVERAGE MONTHLY ORE PRICES.[1]

	Zinc Ore.						Lead Ore.			
	Joplin Base.		Joplin all Ores.		Platteville.		Joplin.		Platteville.	
	1912.	1913.	1912.	1913.	1912.	1913.	1912.	1913.	1912.	1913.
Jan.	$44.90	$53.30	$43.54	$52.22	$45.30	$53.10	$58.92	52.55	$56.50	$51.00
Feb.	45.75	46.88	43.31	44.34	46.44	46.63	52.39	52.66	48.50	52.38
Mar.	51.56	46.50	49.25	44.62	51.63	46.38	54.64	53.22	50.63	52.50
April.	52.00	42.50	50.36	40.92	52.56	42.20	54.18	52.71	53.13	52.70
May.	55.30	43.69	53.27	41.76	54.25	42.25	52.45	51.84	52.72	52.63
June.	55.88	41.75	54.38	40.30	55.75	42.19	55.01	52.22	53.63	52.50
July.	58.85	43.55	56.59	40.88	57.74	43.35	58.83	52.39	58.10	52.50
Aug.	55.13	47.06	53.27	44.54	55.63	46.13	57.04	55.79	57.43	55.25
Sept.	59.75	46.13	57.07	44.30	59.13	46.75	61.28	56.59	63.00	58.00
Oct.	57.00	42.10	55.97	40.07	56.80	42.20	63.22	52.94	63.75	54.60
Nov.	55.69	41.81	53.98	39.99	55.19	41.50	56.55	51.49	56.00	52.75
Dec.	54.63	39.19	52.39	37.50	56.00	38.50	52.42	49.46	51.00	48.00
Year...	$53.87	$44.54	$51.95	$42.62	$53.87	$44.26	$56.41	$52.82	$55.37	$52.90

ORE PRODUCTION OF JOPLIN DISTRICT BY CAMPS AND STATES FOR 1913.[2]

Camps.	Tons, Zinc Blende.	Tons, Calamine.	Tons, Lead.
Webb City, Mo.	79,639	4	22,066
Joplin, Mo.	73,690	1,611	6,949
Miami, Okla.	21,934	.....	7,89[illegible]
Galena, Kas.	18,182	85	3,107
Duenweg, Mo.	17,659	2,194	3,514
Alba-Neck City, Mo.	15,046	407	210
Oronogo, Mo.	12,703	.....	1,344
Carl Junction, Mo.	10,856	.....	115
Lawton, Kas.	3,450	.....	36
Granby, Mo.	3,136	10,854	680
Cave Springs, Mo.	3,444	.....	197
Spring City, Mo.	2,192	2,178	1,275
Carthage, Mo.	1,017	.....	18
Sarcoxie, Mo.	1,782	73	.....
Quapaw, Okla.	519	.....	91
Aurora, Mo.	516	1,743	146
Wentworth, Mo.	452	313	.....
Springfield, Mo.	404	32	14
Badger, Kas.	45	4	7
Total	267,666	19,498	47,661
Values	$11,523,497	$441,530	$2,492,976

Montana.—In spite of unfavorable prices for spelter, Montana showed a great gain in production of zinc, being credited for 1913 with

[1] Joplin base and Platteville zinc prices are on standard ores, 60 per cent. zinc. Second Joplin price is average for all zinc ores sold.

[2] Otto Ruhl, *Min. Eng. World*, No. 4, Vol. XL.

35,756 tons, as against 14,196 tons in 1912. The increase in the magnitude of the zinc mining industry in this state is due largely to two mines in the Butte district, the Butte & Superior and the Elm Orlu. In the course of the year the former more than doubled its output and is now in the front rank of zinc-producing companies of United States. The Elm Orlu Co. expects shortly to have its new 500 ton mill in operation, when its production will also become heavy. The new wet concentration and flotation mill of the Butte & Superior treated 500 tons daily for the first half of the year, and 1000 tons the latter part, and a good recovery was made. The production of the mill in December was 11,400 tons of concentrates, running 51 per cent. zinc. It is understood that some of the big copper mines have developed large resources of zinc ore and it is confidently predicted that Montana will rival the largest of the zinc producing states. By displacing Wisconsin, Montana now ranks fourth in zinc production.

After an exhaustive series of experiments extending over more than a year, the W. A. Clark interests have finally decided in favor of the froth flotation process for the treatment of their zinc copper ores in the Elm Orlu mine, and the mill equipment is being installed by the Minerals Separation, Ltd. When finished, Butte will have the most modern and up-to-date flotation plant so far erected.

It has been known for a long time that in the Walkerville part of this district there were large tonnages of zinc ore. F. Augustus Heinze was the first to spend much money in testing out the possibility of treating the Butte zinc ores profitably, experimenting with the complex ores of the Lexington mine, one of the most famous silver producers of the camp. He was not able, however, to work out a successful commercial treatment. The next to take up the zinc problem were the Clarks, working on the ores of the Elm Orlu mine, where owing to the low-iron content the proposition was more of a straight milling one, rather than one entailing magnetic separation. However, the intimate association of the minerals necessitated such fine crushing that losses were high. The burning of the Butte Reduction Works brought an end to this large scale experimental work. Since that time they have continued the work particularly along the line of flotation methods, the present plan being to use jigs for the first treatment, followed by tables and slime-saving machines. Then the fine tailings are treated by the Mineral Separation Co's. flotation process. The Elm Orlu and Butte & Superior flow sheets differ radically in the water concentration, but it is evident that their success assures that these low-iron zinc ores can be commercially handled. The result of the boom in the camp is much prospecting and development work in surrounding districts.

New York.—Although there was no commercial production from this state, the Northern Ore Co., in the Edwards district of St. Lawrence County, New York, have been doing development work, and experimenting with concentration of the ore. This consists of blende and pyrite, in a vein 4 to 7 ft. wide, and it is now opened up by two shafts to a depth of 400 ft. A successful solution of the rather difficult concentration problem will result in a considerable production from this mine in future years.

Nevada.—The production of zinc was 5828 tons compared with 6132 tons in 1912. Practically all of the output is from the Yellow Pine district, from carbonate ores. The Yellow Pine Mining Co. was the largest producer. During the summer the mill was enlarged and the mine developed so that now the company has a larger ore reserve than ever before. The Potosi mine was purchased by the Empire Zinc Co., and two concentrating plants were erected in the Yellow Pine district, at the Singer and Hoosier properties. These plants are of peculiar interest in that they are using the Stebbins dry concentrators.

New Jersey.—All of the zinc from New Jersey is produced by the New Jersey Zinc Co. from its mines at Franklin Furnace, and Stirling Hill, N. J., in Sussex County. The state is credited in the U. S. Geological Survey report with 24,247 tons of spelter for 1913, against 16,941 in 1912, making it stand fifth in the country in spelter production. However, the total recoverable zinc content of the mine output for the year was reported as 73,240 tons, much of it being made into zinc oxide. Therefore New Jersey on this basis is second only to Missouri in zinc production in the United States. The old mines at Stirling Hill, 2 1/2 miles from Franklin Furnace, are being re-opened, and an up-to-date shaft sunk. Extensive filling is going on in the workings at Franklin. The peculiar form of the ore-body, and the exact knowledge concerning its depth and extent laterally, enable the management to plan the mining so as to recover a maximum amount of the ore.

The only notable change made in the milling of the ore is the removal of the Wilfley tables, their place being taken by New Century Jigs. Willemite concentrates to the amount of 17,713 tons were exported to Europe during the year.

Oklahoma.—All of the zinc production of this state comes from Ottawa County, in the northeastern part of the state, the mineralized area here being a continuation of the Joplin district of southwestern Missouri. Although some production of zinc has been made from Murray County, none came from there during 1913.

There are three mining camps in this district, the Miami, Peoria, and Quapaw. Mining in the Peoria camp was confined almost entirely to the silicates and carbonates of zinc on a small scale. Miami is by far the

most important at the present time. This camp is located on a level stretch of land north of the town of Miami, and was accidentally discovered in 1907 while drilling a well. Most of the production comes from lands controlled by the Emma Gordon Mining Co., and the Commerce Mining & Royalty Co. Considerable trouble has been met with in keeping down the water in the mines, but at the present time it is well under control, and operations to a depth of 320 ft. are made possible. Much exploration work has been done around Miami, and this has proved that the ore-bearing area is fully 22 square miles in extent, and covering a general northeasterly and southwesterly direction over 11 miles. At the close of the year thirty-one prospect drill rigs were at work, and of these ten entered the field within the last 4 months. The Pitcher Lead Co. has secured control of 2000 acres of land, and started exploration with five drill rigs.

The U. S. Geological Survey credits Oklahoma with a production of 6397 tons of zinc for 1913, over three times that of 1912. R. R. Heap gives the production of the Miami, Quapaw and Peoria camps as follows:

PRODUCTION OF MIAMI CAMP, OKLAHOMA.

			Lb.	Value.
Zinc	Jan. 1—Dec. 1		42,520,980	$678,710.40
Zinc	Dec. 1—Dec. 31	(Est.)	4,252,100	67,870.00
	1913—Total zinc		46,773,080	746,580.40
Lead	Jan. 1—Dec. 1		13,462,980	348,876.31
Lead	Dec. 1—Dec. 31	(Est.)	1,346,290	34,887.63
	1913—Total lead		14,809,270	383,763.94
	Total concentrates 1913		61,582,350	$1,130,344.34

PRODUCTION, QUAPAW-LINCOLNVILLE.

			Lb.	Value.
Zinc	Jan. 1—Sept. 1		994,180	$21,870.00
Zinc	Sept. 1—Dec. 31	(Est.)	330,000	6,600.00
	1913—Total zinc		1,324,180	28,470.00
Lead	Jan. 1—Sept, 1		121,290	3,153.54
Lead	Sept. 1—Dec. 31	(Est.)	30,000	780.00
	1913—Total lead		151,290	3,933.54
	Total concentrates 1913		1,475,470	$32,403.54

PEORIA.

Total concentrates Zn and Pb (Est.) 400,000 lb., value $7500.

Tennessee.—Tennessee made a large gain in zinc production as the result of recent operations at the new Mascot mill of the American Zinc Co. of Tennessee; at the Grasselli Chemical Co.'s mill; at the old iron mines of the Embree Iron Co., at Embreeville. The production for the state in 1913 is given as 2635 tons, compared with 1935 tons of zinc in 1912.

The most important development in the state is the recent discovery of zinc ore near Embreville, 19 miles southwest of Johnson City in the

valley of the Nolichucky river. It occurs in a dark dolomitic limestone, and the deposit is said to closely resemble the famous Bertha, Va. deposits. Considerable enthusiasm has been aroused by the prospecting since done, and local investigators believe an important zinc district will be developed.

Texas.—This state is credited with a production of 303 tons of zinc during 1913, a gain over the 245 tons accredited to it the previous year. A valuable discovery of zinc ore near La Grange is reported, and some interest has been aroused in the Buck prospect in Culbreson County, about 12 miles north of Boracho, Texas.

Utah.—The production of zinc in 1913 was 9503 tons, a substantial increase over the figure of 7756 for 1912. The Horn Silver mine in Beaver County was the largest producer of sulphide ore, while most of the silicate and carbonate ores came from the Tintic district. The ores are all secondary, smithsonite forming 90 per cent. of the zinc minerals, and the deposits are all very irregular. The Yankee, May Day, Gemini, Ridge & Valley, and many other mines produced zinc ore during the year. Encouraging finds are reported from the Tintic Standard and the Grutli district. At the Scranton mine electrical equipment was installed during the summer, and a large zinc output is expected for 1914.

In Salt Lake County, the Midvale plant of the United States Smelting and Refining Co. has a Huff electrostatic plant treating 50 tons of zinc-iron middlings per day, part furnished by the company's concentrator at Bingham, and part from other local sources. The separated zinc product runs nearly 50 per cent. zinc, with 3 to 5 per cent. iron.

Virginia.—The U. S. Geological Survey report credits Virginia with 116 tons of spelter for the year, nearly double that produced last year. The increase came in part from the well-known mines of the Austinville district, partly from the oxidized ores occurring in certain iron mines, and also somewhat from the pyrite-zinc mines of Louisa County, where there has been considerable activity of late. However the total recoverable zinc in the ores mined is much in excess of the figures above mentioned, being reported as 810 tons, some of which was made into oxide.

Wisconsin (By J. E. Kennedy).[1]—The net tonnage of zinc ore shipped to smelteries from the Wisconsin district in the first 11 months of 1913 was 136,355,310 lb., a decrease of 48,026,880 lb. from the figures given for the corresponding period of last year. The gross tonnage of zinc ore produced and shipped by mining companies to smelteries and to custom roasters was 192,354,230 lb., a decrease of 31,261,080 lb. The tonnage of lead ore shipped was 5,123,080 lb., a decrease of 2,368,080 lb., while the shipment of sulphur ore, 53,034,910 lb. showed an increase of 17,200,460 lb.

[1] Platteville, Wis.

WISCONSIN ZINC-LEAD PRODUCTION.
(First 11 months.)

	Gross from Mines.		Net to Smelters.	
	1912 lb.	1913 lb.	1912 lb.	1913 lb.
Highland	7,755,500	2,613,020	7,570,900	2,613,020
Linden	14,262,130	17,207,210	2,075,000	4,701,520
Harker	12,045,490	5,807,170	7,892,540	2,565,230
Mineral Point	1,214,530	2,223,650	36,609,700	31,268,750
Dodgeville	1,390,930	407,100	1,390,930	227,100
Montfort	2,104,160	2,301,980	1,299,160	1,272,000
Livingston	17,414,850	22,730,460	665,000	.....
Rewey	2,357,000	1,445,740	2,166,000	1,374,740
Platteville	27,722,130	23,319,110	23,897,790	23,075,270
Cuba City	6,561,150	6,331,830	9,358,100	12,762,280
Benton	44,255,870	41,451,090	29,921,120	24,538,590
Hazel Green	32,488,900	29,186,440	16,266,500	14,202,000
Shullsburg	24,030,800	17,025,810	21,346,900	14,086,410
Galena	30,011,870	20,059,620	23,922,550	3,424,400
Potosi	.....	244,000	.....	244,000
Totals	223,615,310	192,354,230	184,382,190	136,355,310

Ore Prices

The first 3 months of the year saw the highest level of prices. The base price of 60 per cent. zinc started 1913 at $56 per ton, but a decline soon began until it reached the low mark of $40 during April and May. In the third quarter the market improved and $49 base was paid. During the last quarter the base price again declined and went below $40 in December. The highest base price of the year was $56, the best premium price being $57.50; the average base price for the first 11 months was $45 per ton.

Field Activity

Considerable prospect and development work was carried on by the larger operating companies, particularly at Benton, New Diggins, and Hazel Green. At Highland the Mineral Point Zinc Co. increased its holdings by the purchase of the lands and mining rights of the Richard Kennedy estate, comprising 550 acres of mineral lands, also the Kreuhl and Minter farms, and the mining rights of the Franklin Mining Co. Extensive improvements in machinery and equipment since made will increase the tonnage of zinc carbonate from these properties, which were idle a year pending settlement and transfer. The big Black Jack mine, four miles south of Galena, Ill., including the fee to 160 acres was also bought by the Mineral Point Zinc Co. Valuable new discoveries were made on the Champion land at New Diggings, also on the Martin, Cottingham and Grotkin farms at Benton, the Brown land at Galena, the

Stephens land at Platteville, the Ross land at Crow Branch and the Biddick land at Mifflin. A total of 65 mills were in operation at various times during the year. Five new properties were equipped with concentrators, viz., the Masbruch, at Cuba City, the Martin and Grotkin at Benton, the Lawrence at Hazel Green and the Great Western at Galena.

PRODUCTION OF ZINC IN EUROPE AND AMERICA. (a)
(In metric tons.)

Year.	Austria.	Belgium.	France.	Germany.	Holland.	Italy.	Russia.	Spain.	United Kingdom.	United States.	Totals.
1898 ..	7,302	119,067	37,155	154,867	6,700	250	5,664	6,031	28,387	103,514	468,937
1899 ..	7,192	122,843	39,274	153,155	6,235	251	6,331	6,184	32,322	117,644	491,331
1900 ..	6,742	119,315	36,305	155,799	6,845	547	5,963	5,611	30,207	111,794	465,443
1901 ..	7,558	127,170	37,600	166,283	7,855	511	6,090	5,354	29,877	127,751	516,049
1902 ..	8,309	124,780	36,300	174,927	9,910	485	8,280	5,569	40,244	143,552	552,356
1903 ..	8,949	131,740	37,416	182,548	11,515	126	9,901	5,134	44,110	143,792	569,971
1904 ..	9,159	137,323	41,600	193,058	12,895	189	10,607	5,887	46,218	164,921	621,857
1905 ..	9,204	142,555	43,200	198,208	13,550	5	7,520	6,184	50,125	183,014	653,565
1906 ..	10,711	148,035	46,536	205,691	14,650	69	9,610	6,209	52,587	204,548	698,646
1907 ..	11,208	154,492	(c)49,733	208,195	14,990	88	10,409	(c)6,000	55,595	226,398	737,108
1908 ..	12,770	161,940	47,880	216,490	17,257	(d)100	9,960	6,357	54,473	190,933	718,160
1909 ..	12,638	167,100	(c)49,718	219,766	19,548	(b)	7,949	(c)6,400	59,350	241,730	784,199
1910(f)	13,305	181,745	(c)51,527	227,754	20,975	(b)	8,128	(c)6,604	(e)63,587	251,348	824,973
1911 ..	15,766	198,230	57,110	235,776	22,734	(b)	9,652	6,333	(e)67,907	268,378	881,886
1912 ..	19,096	205,940	65,565	271,064	23,932	(b)	11,176	6,500	57,231	316,368	976,872
1913(f)	20,000	198,000	70,000	285,000	24,000	(b)	9,000	(g)	59,000	323,200	1,001,200

(a) From the official statistics of the various Governments except 1906 to 1911 inclusive, for which years the figures reported to Henry R. Merton & Co. have been used where the official statistics were unavailable. In addition to the production reported in this table, Australia produced 286 long tons in 1903, 299 in 1904, 544 in 1905, 1008 in 1906, 980 in 1907, and 1086 in 1908. (b) Included in Austria. (c) An approximate separation of the total which is reported for "France and Spain." (d) Estimated. (e) Includes 508 and 1000 tons from Australia. (f) *Eng. and Min. Journ.* (g) Shown with France. Norway also credited with 8000 tons not shown here.

Zinc Mining in Foreign Countries

Australia.—The production of spelter is practically confined to the Broken Hill district of New South Wales, where zinc blende forms one of the chief constituents in the enormous deposits of sulphide ores. Good results have been achieved in the work of profitably extracting the zinc contents of large heaps of accumulated tailings and from the ore raised on the Broken Hill field. For 1913, the amount of spelter produced is estimated at a little over 4000 tons, as compared to 2500 tons in 1912.

Austria Hungary.—The United States Consul at Vienna, Austria, reports that the total output of zinc from Austria was 34,674 tons of ore, valued at $577,451. Of this amount half was devoted to Government uses. Zinc ore in Austria is produced mostly in the Provinces of Carinthia and Tyrol, though it appears in small amounts in Styria and also in other Provinces. Zinc as such is not mined in Hungary. It is obtained in small quantities as a by-product, in 1912 amounting to 857 tons, valued at $13,961. The attitude of the Hungarian Government is very favorable toward persons desiring to develop the zinc resources of the country.

British Columbia.—Zinc mining is receiving increasing attention in British Columbia, over 3000 tons of zinc being produced, the ore being almost all smelted in Oklahoma. Smelter interests from Bartlesville purchased the output from the concentrating mills of the Standard, Hewitt, and Van-Roi mines, in Slocan district, and the Monarch, near Field. The Standard Silver-Lead Mining Co. of Silverton was by far the largest producer. In the early part of the year the Lucky Jim mine shipped ore containing in aggregate nearly 500 tons of recoverable zinc. Experimentation in flotation of ores is in progress at several localities, and a successful solution of this problem would result in increased production.

China (By T. T. Read).—There has always been a considerable production of spelter in China by native methods, and the exports have almost quadrupled in the past 3 years. The output comes from Kweichou province, a part of the country which is very little known to foreigners, and except for the descriptions by Duclos and Leclere almost nothing is known about the Chinese zinc industry. Zinc ore occurs abundantly in Heng-Chou and Yang-Chou prefectures of Hunan province and considerable quantities of the ore are exported to Belgium and Germany, the figures being as follows: 9631 tons in 1910; 4705 tons in 1911; 7057 tons in 1912. The exports of spelter for the same years were 206,699 and 748 tons respectively, practically all of it going to Japan.

Italy.—Consul General Jones, Genoa, Italy reports that in 1913 the production of zinc ores in Italy reached a total of 100,000 tons, all of which was shipped from Carloforte, Sardinia, to French and Belgian smelters, one-third to France and two-thirds to Belgium. No smelting is done in Italy. Some zinc ore is mined in Bergamo, and is said to be shipped from Genoa to Swansea, Wales.

Mexico.—The unfortunate political conditions in Mexico during 1913 caused a great decrease in the production of all metals, and zinc suffered with the rest. Statistics for the year are very meager, but the Government report for the period June, 1912–June, 1913 gives the value of zinc exported as 536,094 pesos, a decrease of 372,600 pesos from the figure of the preceding 12 months. The estimated value of Sonora's zinc concentrates was $55,000.

Russia.—Consul L. A. Davis, Batum, Russia, reports that almost the entire production of zinc and silver-lead ores is obtained from the mines of the Alagir Co. near Sadon, in the Vladikavkaz district of the Tersky province. These metals are not exported.

In the Warsaw consular district, zinc mines exist only in the district of Olkusz. There are two known mines of zinc, the Boleslaw and the Ulisses. In 1912 the two mines yielded 48,427 tons of carbonate of zinc

and 18,768 tons of carbonate of zinc containing some lead. The smelting works, owned mostly by French, or other foreign corporations, turned out 23,910 tons of zinc and 726 tons of zinc dust in 1912.

Spain.—From the Production statistics of 1912, the latest available, it appears that 175,311 long tons of zinc ore were mined in Spain that year. The number of productive mines in the country was 44. The most important production of zinc ore is in the province of Murcia, Santander and Cordoba. The exports of ore declined in 1913, due to prevailing low prices, being only 4000 tons, compared to 5000 tons for the previous year.

Bibliography of Zinc in 1913

Burgess, C. W.—Mining Costs in the Joplin District. *Col. School of Mines Magazine*, April, 1913.

Chapman, Temple.—Conditions in the Joplin District. *Eng. Min. Jour.*, **96**, No. 9.

Clerc, F. L.—Igneous Concentration of Zinc Ores. *Eng. Min. Jour.*, **95**, No. 4.

Hale, E. W.—Copper Matte and Base Bullion from an Electric Spelter Furnace. *Min. Sci. Pr*

Hoover, T. J.—Concentrating Ores by Flotation. 221 pp. *Mining Magazine.*

Johnson, W. McA.—By-products in Electric Zinc Smelting. *Eng. Min. Jour.*, **96**, No. 25.

Johnson, W. McA.—Johnson Electric Zinc Process. *Min. Eng. World*, Jan. 10, 1914.

Lakes, Arthur.—Recovery of Zinc, the Great Problem in Mining. *Min. Eng. World*, **38**, No. 3.

Liebig, R. G. Max.—Zinc und Cadmium. 598 pp.

McDonald, P. B.—Zinc Mining in New York. *Eng. Min. Jour.*, **97**, No. 7.

Merton, A. M.—Specifications and Tests for Zinc Dust. *Min. Eng. World*, **38**, No. 26.

Nettell, A. J. C.—Treatment of Zinc Ores. *Can. Min. Jour.*, Feb. 1, 1914.

Pulsifer, H. B.—Development of the Wisconsin Zinc Field. *Min. Eng. World*, **38**, Nos. 25, 26; **39**, Nos. 1, 2, 3.

Reid, F. W.—Port Pirie Plant of Broken Hill Proprietary Company. *Min. Sci. Pr.*, Mar. 21, 1914; *Min. Eng. Rev.*, Oct. 6, 1913.

Rice, Claude T.—Newer Developments at Butte Mines. *Min. Eng. World*, **39**, No. 3.

Ruhl, Otto.—Review of Missouri Kansas District for 1913. *Min. Eng. World*, **40**, No. 4.

Snider, L. C.—Mining in Oklahoma in 1913. *Min. Eng. World*, **40**, No. 4.

Udden, J. A.—The Buck Zinc Prospect near Boracho, Texas. *Min. Sci. Pr.*, Mar. 21, 1914.

Utter, Geo. H.—Producing Zinc in the West without Tariff. *Min. Sci.*, August, 1913.

Zalinsky, E. R.—Occurrence of Oxidized Zinc Ores at Tintic. *Eng. Min. Jour.*, **95**, No. 25.

Zook, Jesse A.—The Joplin District in 1913. *Eng. Min. Jour.*, **97**, No. 2.

———. "Electrostatic Separation in Treatment of Complex Sulphide Ores Containing Heavy Percentage of Zinc." *Min. Sci.*, Dec. 1, 1913.
———. "Dressing Western Zinc Ores." *Min. Sci. Pr.*, Mar. 1, 1913.

THE METALLURGY OF ZINC IN 1913[1]

BY W. R. INGALLS

Our great problem at the present time is without doubt the treatment of flotation concentrate. This is excessively fine, ranging from 80 to less than 200 mesh, and produces the troubles that fine ore always does metallurgically and in addition thereto some that are peculiar to the metallurgy of zinc. It is difficult to roast such ore, and there are also troubles in the distillation of it. The loss of zinc in roasting is particularly large. This appears to be due not merely to dusting, but also to reduction and volatilization. How to get around the difficulties is not yet known, but our metallurgists are philosophic about the matter, recognizing that the supply of flotation-concentrate is bound to increase and that they have got to learn how to treat it.

Last year, 1913, was unprofitable to the smelters, smelting margins dwindling about to the vanishing point, and during the last quarter about one-third of the smelting capacity was put temporarily out of use. The commercial conditions prevented the new Granby smeltery, at East St. Louis, from being fired up, although it was practically completed. The erection of a new plant at Burgettstown, Ohio, was begun and another one is projected near Wheeling, W. Va. The reduction of the tariff on zinc ore will probably make the Ohio valley between Pittsburgh and Wheeling become an important zinc-smelting center.

Retort Residues.—The Edgar Zinc Co. has been experimenting with the use of retort residues, which contain a good deal of unburned coal, as fuel under the steam boilers. About 20 per cent. of fresh coal is added. So far, this mixture has proved serviceable, and 10 boilers are now fired in this way. The retort residues are screened, everything above 1/4-in. size being used. At the zinc-oxide works at Coffeyville, Kan., the residues from the Dearing plant of the American Zinc, Lead & Smelting Co. are being burned for recovery of their zinc as oxide. Several persons have been trying to secure the residues of the smelteries in the gas field for this purpose, these residues being unmixed with coal clinkers, but the several smelting companies are averse to letting them go. A small quantity of oxide is recovered at the works of the Edgar Zinc Co.

More or less attention was given during 1913 by several zinc smelters to the possibility of firing their furnaces with pulverized coal, after the

[1] *Eng. Min. Jour.*, Jan. 10, 1914.

fashion of the cement makers. The Edgar Zinc Co. is actually going to try this at Cherryvale, having arranged one distillation furnace and one roasting furnace for the experiment, for which it is figured that all will be ready early in 1914.

Metallurgical Mechanism.—The National Zinc Co. made a successful introduction of the Saeger charging machine at its works in Bartlesville, Okla. This machine is said to charge the retorts better than can be done by hand and in less time, one machine charging a furnace in 1 hour, while hand charging takes 2 hours at least. It is expected that the use of the machine will eventually effect a saving of two men on the furnace. The common arrangement of the distillation furnaces in American works is unfavorable to the use of a charging machine, American practice being to set the furnaces in parallel, whereas in the European practice they are commonly set in series, *i.e.*, in a single row. It is estimated at Bartlesville that if the furnaces there were set in the European way, one charging machine could easily serve four or five furnaces.

The Garrison & Whipple condenser machine found further application during 1913, it having been installed at several smelting works.

The State of the Art.—George C. Stone, in a paper read before technical societies in New York, in November, 1913, gave some data respecting present practice in zinc smelting in the United States. He said that "to-day 87 per cent. extraction of the zinc is only fair and many works can show runs of long periods averaging 90 per cent. and over. The fuel consumption has been largely decreased, mainly by the adoption of regenerative gas-firing. A comparison of furnaces using the same kind of coal shows that where the hand-fired furnaces 25 years ago required 2, 3 1/2 and even 4 tons of coal per ton of ore, well equipped gas furnaces using the same coal and working the same class of ore now take only 1 1/2 to 1 3/4 tons. Labor has also been largely reduced. The old Belgian furnaces required 5 days' labor per charge, two men working 24 hours continuously, and an extra helper on the day shift only. As these furnaces worked only about a ton of ore, they required 5 days' labor per ton. At present all 24-hour work is done away with, and not over 1 1/2 days' labor is required per ton. In 1844, 15 to 20 days was the usual life of a retort. Now good retorts made in hydraulic presses last from 30 to 40 days, and at that more are replaced because they are filled up than because they leak."

Electric Smelting.—A good deal of literature about electric smelting was published in 1913, showing the wide interests in this subject. Petersen conducted experiments at Butte, Mont. They were instructive, but in the opinion of the Butte & Superior management they were not com-

mercially promising and consequently were abandoned. Johnson continued the operation of a 1-ton furnace at Hartford, Conn., running at intervals. The erection of an experimental furnace at Nelson, B. C., by the Canada Department of Mines was begun.

Queneau, Specketer and others continued experimental work in Europe. Renewed attention was drawn to the Côte-Pierron process, for which a 400-K.W. furnace was installed at Ugine, Savoy. Regular operations were continued at Sarpsborg, in Norway, and at Trollhattan, in Sweden, where several thousand tons of electrically smelted spelter are produced annually. A new plant which is to have 17 furnaces of 1000 h.p. and 8 furnaces of 500 h.p. is about being completed at Trollhattan. The company owning these Scandinavian works reported recently that its smelting operations have not yet proved commerically profitable, but the results in August, 1913, were better than in any previous month, and it is hoped that things will eventually turn out well.

Hydro-Metallurgical Processes.—Among processes of this kind, the chief attention in 1913 was devoted to the so-called bisulphite process, and to S. E. Bretherton's ammonia process. Reports that reach me from Great Britain indicate some measure of success with the bisulphite process, which has been carefully worked out. Mr. Bretherton does not appear yet to have put this process in commerical, or even semi-commercial, operation. From the theoretical standpoint, both of these processes are rational. I imagine that their future depends upon their ability to obtain a sufficient proportion of the zinc in solution and the cost of performing the several steps of the process. These factors are likely to vary according to the ore.

Another class of hydro-metallurgical processes is those in which the zinc having been obtained in solution, precipitation is effected by electrolysis. The Siemens & Halske, and Isherwood processes are of this class. Experimental work in this direction has also been done at Bully Hill, Calif. There seems to be no longer any difficulty in obtaining a dense coherent zinc cathode, if the electrolysis be conducted in the right way. However, the same remarks made with reference to the other hydro-metallurgical processes, apply to these also. Experiments were conducted at the Raritan works, Perth Amboy, with the Isherwood process, during a considerable part of 1913. No account of the work there has been published, which is a pity, for it was without doubt of great interest.

PROGRESS IN ORE DRESSING AND COAL WASHING IN 1913

By Robert H. Richards and Charles E. Locke

General

The results of the past year indicate that the millmen are seeking for improvement along three lines: (1) improvement of present methods; (2) introduction of new methods; (3) the supplementing of ore dressing by other processes, especially by hydrometallurgical processes. There seems to be a tendency for the ore dresser to get inspiration from the gold mill man. The tube mill and Hardinge mill were among the first gold-milling machines whose value was realized for grinding before concentration and now we find that mechanical classifiers, thickeners and filters which have proved their value in gold mills are being investigated with respect to their value in concentrating mills.

At the Butte meeting of the American Institute of Mining Engineers, the Anaconda company gave to the public the results of years of work of their large testing force. This not only forms a splendid example for other companies to follow, but it shows the economic value of a testing staff. The additional recovery of fine free mineral alone, which is now being made by this company by desliming the pulp before classifying probably goes a long way toward paying all the expenses of testing. The slime-treatment system and the Laist acid-leaching system at Anaconda, and the regrinding plant and leaching system at the Calumet & Hecla are marked steps in progress in additional recovery from material which formerly went, at least in part, to waste.

Flotation, especially the froth process, has extended its field and the practical application is better understood. It is realized that flotation apparatus is more delicate than jigs and tables and therefore requires more attention and even then may give variable results.

Crushing and Grinding

Rock Breakers.—Underground crushing has been installed in the Crown mine, South Africa, where, at the thirteenth level, the crushing plant consists of two grizzlies with 8-in. spaces and two 21 1/2 ×

39 1/2-in. jaw breakers, each driven by a 60-h.p. motor.[1] The Knights Deep mine of the Witwatersrand Gold Mining Company also has an underground crushing station. At Round Mountain, Nevada, the Round Mountain Company has been operating two such stations. No difficulty has been met. Where dust is troublesome atomizers are used. The advantages of the system are that large lumps of ore are broken before hoisting and waste may be sorted out to be used directly for filling and thus save the expense of hoisting it to the surface.

Rolls.—Regarding the use of various mechanical devices on crushing rolls to give one roll an end motion in order to prevent corrugating the faces of the roll shells, H. C. Holthoff[2] says that they do not attain the desired end and at the same time they add complication to the mechanism. He claims that the cause of corrugations is abrasion which in turn is due to two causes: (1) feed lumps too large to be nipped without slippage; (2) differential speeds of the two rolls. The latter trouble may be obviated by using a small narrow belt to drive one roll. In this case the belt slips during crushing and allows the peripheral speed of the two rolls to remain the same. Chilled iron and manganese steel for roll shells have hard surfaces and allow more slip than low carbon rolled steel which is softer and soon becomes rough, thus increasing friction and reducing slip.

Gravity Stamps.—California stamp mill practice on the mother lode[3] still continues along the line of stamping, amalgamation, and concentration. Cyaniding is usually reported to give unsatisfactory results, although the new Black Oak 75-ton mill is an all-sliming cyanide plant and the Bunker Hill mill has cyanided tailings for a long time. The Frue vanner is the usual concentrator although some Johnston vanners, some Wilfley tables, and some Deister tables are used. The new Pacific side shake vanner is doing satisfactory work in two mills. Stamps weigh between 900 and 1200 lb., the newer mills having the heavier stamps. New installations have concrete mortar blocks, older mills have anvil blocks on concrete or wooden blocks on concrete. Wooden guides have been almost entirely replaced by iron guides with removable bushings of the Miners, Knight or Pacific types. The stamp duty is between 3 and 5 tons in 24 hours.

Discussion of last year's paper on the metallurgy of the Homestake ore[4] has raised the questions whether in the light of recent practice elsewhere, it would not be wise, if the plant were being erected now, to use much heavier stamps and to reduce the area of amalgamated plates, and thus

[1] Warriner. *Eng. Min. Jour.*, XCVI, 118 (1913). *Jour. So. Afr. Inst. Eng.*, April, 1913. *Min. Sci. Pr.*, CVI, 938 (1913); CVII, 118 (1913). *Min. Mag.*, IX, 376 (1913). *So. Afr. Min. Jour.*, Oct. 4, 1913.
[2] *Eng. Min. Jour.*, XCV, 1302 (1913).
[3] L. H. Eddy. *Eng. Min. Jour.*, XCV, 405 (1913).
[4] A. J. Clark and W. J. Sharwood, *Inst. Min. Met.*, XXII, 68 (1913).

arrive at the same total recovery but accomplish a greater percentage of the recovery by cyaniding.

A comprehensive article on stamp milling on the Rand has been contributed by H. S. Gieser.[1]

The Pinder-Berry gravity stamp[2] obtains high capacity by the use of a single-stamp circular mortar and screen, by introducing the feed water at the bottom of the mortar, by feeding the ore through a central vertical opening in the shoe, and by using a threaded stem and cushioned tappet, which when used with a special cam allows the high speed of 138 drops per minute. Taper keys hold the tappet in place. Tested against ordinary gravity stamps this stamp gives a capacity of 5.89 tons per 24 hours per horse power against 2.97 tons, both using a 30-mesh screen. The mechanical efficiency of the crushing is not stated but undoubtedly the Pinder-Berry stamp gives a much coarser product. The idea of threaded tappets is not new. When tried in the past it was found difficult to keep them from working loose. Possibly the use of tapered keys has overcome this trouble.

From time to time attempts have been made to design a sectional cam for easy removal. The Berrill cam is the latest type and is reported to be working satisfactorily at Kalgoorlie.[3] It is rather difficult to describe without a figure but in principle it consists of two parts with the line of division at right angles to the cam shaft. Each part consists of a regular lifting arm, a Blanton key connection to the shaft, an opening from one side of the center hole to allow the part to be removed laterally from the cam shaft and finally another thinner arm or wing 180 degrees from the lifting arm, which fits underneath and locks with the regular arm of the other part. In the act of lifting the stamp these two parts are jambed together. A small copper rivet also is necessary to hold the two parts together to prevent chattering but not to bear any strain.

The design of the involute stamp cam and the analysis of the proper curve and of the velocities of the stamp during its cycle have been discussed by S. L. Berry.[4] For practical use a chart has been prepared showing the maximum number of drops per minute possible with different inscribing circles. These are all based on a maximum lifting velocity of 2.6 ft. per second which is all that the usual form of tappet will stand without slipping.

An illustrated description of the City Deep concrete mortar block in South Africa has appeared.[5] The usual wooden posts are replaced by

[1] *Mex. Min. Jour.*, XVI, 72 (1913)
[2] S. L. Berry, *Min. Sci. Pr.*, CVI, 739 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 89 (1913).
[3] M. W. Von Bernewitz, *Min. Sci. Pr.*, CVI, 995 (1913); *Jour. Chem., Met. Min. Soc. So. Afr.*, XIV, 214 (1913).
[4] *Min. Sci. Pr.*, CVI, 831 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 155 (1913).
[5] *Eng. Min. Jour.*, XCV, 951 (1913).

concrete extensions upward from the mortar block and these extensions support a steel frame which carries the cam shaft with the regular boxes on the posts and also four intermediate boxes. This construction, although apparently very massive, was reported last year to be causing trouble through cracking of the concrete. The long 50-in. heads in this mill have been changed for shorter ones. It is significant that instead of the 2000-lb. stamps used in this mill, two later mills erected by the same company have 1650-lb. and 1670-lb. stamps and the steel frame support for cam shaft has been abandoned.

The latest arrangement for by-passing the fines in Rand stamp mills is to use a conical trommel 22 in. long and 24 and 36 in. diameter with slots 0.29 × 0.75 in., the same size as the battery screen. Only the oversize passes through the stamps.

The construction of foundations of New York and Honduras Rosario mill under difficult conditions on a steep hillside has been described by R. B. Rogers.[1] The stamp mortar for 1800-lb. stamps is of concrete and has a longitudinal tunnel 30 in. square. The anchor bolts for mortars and posts are about 5 ft. long and extend downward in iron pipes, slightly converging, through the roof of the tunnel.

The anchor bolts for the mortar in the Original Stamp mill pass through boiler tubing set on an incline in the concrete mortar block.[2] To avoid breakage of bolts and to maintain uniform tension in the 1¾-in. bolts, two coiled springs, one nesting in the other, are placed on the lower end of each rod and screwed up to give a tension of 17,000 lb. Heavy steel spiral springs of 1-in. thickness are also used at new Big Four mill at Manhattan, Nevada, on all anchor bolts for mortars.

Fine Grinding.—The accompanying table, compiled from various sources shows the practice in fine grinding in several districts on this continent. The coarse crushers have not been included because in almost every case they were some form of breaker. The points to be observed are that stamps are mostly crushing through coarse screens and play the rôle of intermediate machines and that the stamp-tube mill combination is the favorite. Ball mills do not appear at all. Huntington mills are rare and pans are used only in a few instances. Amalgamation is less used. The popularity of stamps and tube mills is undoubtedly due to the satisfactory results which they yield but there is perhaps also the element of reliability which enters into the question. The mill designer can absolutely guarantee that they will work on any class of ore and therefore he will install them rather than take the risk of putting in something else which he considers less expensive and more efficient, but which, nevertheless, he is not absolutely sure will prove successful.

[1] *Min. Sci. Pr.*, CVI, 472 (1913).

[2] H. A. Kuns, *Min. Sci. Pr.*, CVI, 348 (1913).

Mill.	Ore.	Process.	Tons, 24 Hours.	Crushing Stages after Breakers.
PORCUPINE DISTRICT, ONTARIO				
Hollinger	Gold. Soft quarts and schist with pyrite.	Concentration, cyaniding of concentrates and tails.	380	(1) 40 stamps, 1500 lb. to 6 mesh. (2) 4 tube mills, 5 × 20 ft., for tails and 3 pans, 5 ft., for concentrates.
Dome	Gold. Quarts and schist with pyrite.	Amalgamation and cyaniding.	400	(1) 40 stamps, 1250 lb., to 10 mesh. (2) 4 tube mills, 5 × 22 ft. 92% through 100 mesh, 60% through 200.
McIntyre	Gold. Quarts and pyrite.	Cyanide	150	(1) Rolls. (2) Chile mill, 6 ft., to 6 mesh. (3) Tube mill to 100 mesh.
Vipond	Gold. Quarts...	Amalgamation...	.....	(1) Rolls to ¾ in. (2) 2 Hardinge ball mills. (3) 2 Hardinge tube mills 6½ × 6 ft. 80% through 200 mesh.
BLACK HILLS, SOUTH DAKOTA				
Homestake	Gold. Slates and schists with pyrite.	Amalgamation and cyaniding.	4200	(1) 1000 stamps, 850 lb., to 30 or 35 mesh. (2) 8% coarse sand to 7 pans, 5 ft., and 1 tube mill, 5 × 14 ft. 42% through 200 mesh. Pans being discarded for tube mills.
Minnesota	Gold. Siliceous.	Cyanide	75	(1) 2 rolls to ½ in. (2) 2 Chile mills, 10 ft., to 6 mesh. 61% through 100 mesh, 46% through 150.
Wasp No. 2	Gold. Porous ore.	Cyanide	.....	(1) 2 rolls. (2) 2 rolls to ½ in.
Victoria	Gold. Hard siliceous.	Cyanide	200	(1) Rolls to ¾ in. (2) Rolls to 6 mesh.
Golden Reward	Gold. Mixed siliceous.	Cyanide	.....	Chile mills with 0.021-in. slots. 74% through 100 mesh, 54% through 200.
Trojan	Gold. Mixed siliceous.	Cyanide	450	(1) 2 rolls. (2) 2 Chile mills, 7 ft., with 0.021-in. slots. Propose coarser screen on Chils followed by tube mills to 60 mesh.
Bismark Consolidated.	Gold. Soft, porous oxidised.	Cyanide	.....	Two rolls in tandem to ½ in.
New Reliance	Gold. Mixed and mostly hard.	Cyanide	100	30 stamps, 1000 lb., 0.023 in. 56% through 100 mesh, 33% through 200.
Lundberg, Dorr and Wilson.	Gold. Mixed.....	Cyanide	100	(1) Rolls to ½ in. (2) 1 Chile mill, 6 ft., to 30 mesh. 67 to 74% through 100 mesh, 33 to 34% through 200.
COLORADO				
Stratton's Independence.	Gold. Siliceous with sulphides and tellurides.	Concentration, cyaniding of tails	300 to 400	(1) Rolls to ½ in. (2) 4 Chile mills, 6 ft., to 12 mesh. 67% through 100 mesh, 62% through 150. (3) Middlings to 1 tube mill, 5 × 15 ft. 92% through 150 mesh.
Portland	Ditto.	Concentration, cyaniding of tails	360	(1) Rolls to ½ in. (2) 4 Chile mills, 6 ft., to 20 mesh.
Colburn Ajax	Gold. Granite porphyry.	Concentration, cyaniding of tails	250	(1) Three rolls to 6 mesh. (2) Tube mills, 5 × 16 ft. 85% through 150 mesh.
Argo	Gold and silver. Mixed quarts and sulphides.	Concentration, amalgamation, cyaniding of tails	135	(1) 20 stamps, 1000 lb., to 12 mesh. (2) 1 tube mill, 3 × 10 ft., for middlings sand.

Mill.	Ore.	Process.	Tons, 24 Hours.	Crushing Stages after Breakers.
Hudson.....	Ditto.	Amalgamation, concentration, cyaniding.	88	(1) 20 stamps, 850 lb., to 12 mesh. (2) 1 pan, 5 ft., for middlings.
Liberty Bell.....	Gold and silver. Soft quarts and sulphides.	Amalgamation, concentration, cyaniding of tails	485	(1) 80 stamps, 850 lb., to 12 and 14 mesh. (2) 1 tube mill, 5 × 22 ft. (3) 1 tube mill 5 × 22 ft. 88% through 100 mesh, 73% through 200.
Tomboy.....	Gold and silver. Mixed sulphides and gangue.	Amalgamation, concentration, cyaniding of tails	.....	(1) 60 stamps. (2) 2 Hardinge mills.
Smuggler Union....	Ditto.	Amalgamation, concentration, cyaniding of tails	.....	(1) 60 stamps to 16 mesh. (2) Hardinge mill for middlings.
Ophir.....	Gold. Soft quarts.	Cyanide.....	150	(1) 20 stamps, 850 lb., to ¼ in. (2)1 Hardinge mill, 8 ft.

NEVADA

Goldfield Consolidated.	Gold.....	Amalgamation, concentration, cyaniding of tails	850	(1) 100 stamps, 1050 lb., to 4 mesh. (2) 6 Chile mills to 16 mesh. (3) 6 tube mills, 5 × 22 ft., 80% through 200 mesh.
McNamara	Silver. Medium hard quarts with sulphides.	Cyanide.....	75	(1) 10 stamps, 1400 lb., to 8 and 12 mesh. (2) 1 tube mill, 5 × 16 ft.
West End.....	Ditto.	Concentration, cyaniding of tails	150	(1) 20 stamps, 1200 and 1300 lb. (2) 2 tube mills, 5 × 18 ft.
Montana Tonopah..	Ditto.	Concentration of sand. Cyaniding of sand and slime	150	(1) 40 stamps, 1100 lb., to 25 mesh. (2) 2 tube mills, 5 × 22 ft. (only 1 used).
Tonopah Extension	Ditto.	Cyanide.....	155	(1) 30 stamps, 1050 lb. to 3 and 12 mesh. (2) 1 tube mill, 5 × 18 ft. 55% through 100 mesh, 36% through 200. (3) 1 tube mill, 5 × 18 ft.. 77 % through 100 46% through 200.
Desert.....	Ditto.	Concentration, cyaniding of concentrates and tails.	500	(1) 100 stamps, 1050 lb. (2) 3 Huntington mills, 5 ft., and 2 Chile mills, 6 ft. (3) 1 Huntington; Chile mills are to replace Huntingtons.
Tonopah.....	Ditto.	Concentration, cyanide.	.....	(1) Stamps. (2) Tube mills. (3) Tube mills. 99% through 100 mesh, 89% through 200.
Tonopah Belmont..	Ditto.	Concentration, cyanide.	.....	(1) 60 stamps, 1250 lb. (2) 8 tube mills, 5 × 18 ft.
Manhattan Big Four.	Gold. Soft calcareous schist.	Amalgamation...	100	(1) 10 stamps, 1050 lb. to 8 mesh. (2) 2 tube mills, 5 × 18 ft.
Manhattan Associated.	Gold. Soft custom ores.	Cyanide.....	50 to 60	(1) 10 stamps, 1050 lb., to 30 mesh. (2) Tube mill, 4½ × 16 ft.
War Eagle.....	Gold. Soft.....	Cyanide.....	.....	(1) 10 stamps, 1050 lb. (2) Tube mill, 5 × 16 ft., and Chile mill, 6 ft.
Nevada Hills.....	Silver. Medium hard quarts.	Concentration, cyaniding of tails	120 to 140	(1) 20 stamps, 1250 lb., to 8 mesh. (2) 2 tube mills 5 × 18. ft.

Mill.	Ore.	Process.	Tons, 24 Hours.	Crushing Stages after Breakers.
Nevada Wonder...	Silver. Medium quarts.	Concentration, cyaniding of tails	110	(1) 10 stamps, 1400 lb. (2) Chile mill to 0.08 in. (3) 1 tube mill, 5 × 22 ft., and Chile mill, to 200 mesh.
Pittsburg Silver Peak.	Gold and silver. Hard quarts.	Amalgamation, cyanide.	550	(1) 120 stamps, 1050 lb., to 4 and 30 mesh. (2) Tube mill to 80 mesh.
		ARIZONA		
Gold Road.....	Gold. Quarts....	Cyanide.....	360	(1) 40 stamps, 1050 lb., to 4 mesh. (2) 4 tube mills, 5 × 22 ft. 87% through 150 mesh.
Tom Reed.....	Gold. Medium quarts.	Cyanide.....	150	(1) 20 stamps, 1250 lb., to 12 mesh. (2) Tube mill, 5 × 22 ft. (3) 1 tube mill 3½ × 16 ft. 99 % through 100 mesh, 70 % through 200.
Vulture.....	Gold. Quarts and sulphides.	Concentration, cyaniding of tails	100	(1) 20 stamps, 1650 lb., to 40 mesh. (2) 2 pans, 5 ft. (3) 1 pan, 5 ft. 85.5% through 100 mesh, 45.4% through 200.
Chispas.....	Silver. Quarts..	Concentration, cyanide.	.....	(1) 20 stamps. (2) Tube mill, 4½ × 20 ft.
		WASHINGTON		
No. Washington Power and Reduction.	Gold and silver. Quarts with pyrite.	Cyanide.....	100	(1) Rolls to ½ in. (2) 1 Chile mill, 6 ft., to 16 mesh. (3) 1 tube mill, 5 × 22 ft. Chile mill unsatisfactory on this hard ore. Probably replace by short tube mill and use 2 tube mills for finishing.
San Poil.....	Gold and silver. Hard quarts.	Cyanide.....	70	(1) Williams hammer mill to ⅜ in. (2) Rolls to 8 or 10 mesh, to be replaced by 6 × 8 ft. pebble mill. (3) 1 tube mill, 5 × 22 ft. Williams mill of doubtful economy.
		CALIFORNIA		
General Practice...	Gold. Quarts and sulphides.	Amalgamation, concentration.	.....	Stamps to about 30 mesh.
Black Oak.....	Gold. Hard granodiorite and sulphides.	Cyanide.....	100	(1) 20 stamps, 1250 lb., 6 and 19 mesh. (2) Tube mill, 5 × 18 ft.
North Star.....	Gold. Quarts and sulphides.	Amalgamation, concentration, cyaniding of concentrates and tails.	300	(1) 80 stamps, 1000 lb., to 30 mesh. (2) 1 tube mill, 4½ × 20 ft., for concentrates.
		MEXICO AND CENTRAL AMERICA		
Lluvia de Oro.....	Gold and silver. Hard.	Concentration, cyaniding of tails	80	(1) 12 Nissen stamps, 1500 lb. (2) 2 tube mills 3½ × 16 ft. 95% through 200 mesh. Formerly 3 slow-speed Chile mills which were unsatisfactory for such work.
Veta Colorado.....	Silver.....	Cyanide.....	400	(1) 80 stamps, 1050 lb., to 14 or 16 mesh. (2) 5 tube mills, 5 × 14 ft. 80 % through 200 mesh.

Mill.	Ore.	Process.	Tons, 24 Hours.	Crushing Stages after Breakers.
Bostwick Guasapares.	Silver. Clayey..	Cyanide.....	75	(1) Rolls to 2½ mesh. (2) Rolls to 14 mesh. (3) Tube mill, 5 × 18 ft.
Purisima Grand....	Hard quarts.....	Concentration, cyaniding of tails	100	(1) 5 Chile mills. 62% through 100 mesh, 47% through 200. (2) 2 tube mills, 4 × 20 ft. 88% through 100 mesh, 75% through 200.
San Francisco.....	Silver. Hard ore and sulphides.	Concentration, cyaniding of tails	220	(1) 40 stamps, 1250 lb., to 6 or 8 mesh. (2) 3 tube mills, 4½ × 13 ft., and 1 tube mill 5 × 15 ft.
Palmarejo and Mexican.	Silver.....	Concentration, cyaniding of tails	.....	(1) 30 stamps, 1250 lb. (2) 6 tube mills, 4½ × 16 ft.
Pozos.....	.....	Concentration, cyaniding of tails	250	(1) 6 Chile mills, 7 ft., to 8 mesh. (2) 4 tube mills, Krupp No. 5.
El Tajo.....	Silver. Hard quarts.	Concentration, cyaniding of tails	100	(1) 20 stamps, 850 and 1050 lb., to 20 mesh. (2) 2 tube mills 3½×16 ft.
El Rayo.....	.....	Cyanide.....	.....	(1) Rolls. (2) 4 Huntington mills. (3) 2 tube mills.
N. Y. & Honduras Rosario.	Gold and silver...	Cyanide.....	200	(1) 20 stamps, 1800 lb., to 4 mesh. (2) 2 tube mills, 5 × 22 ft. (3) 1 tube mill, 5 × 22 ft.

H. A. Megraw,[1] in discussing this question of fine grinding inclines to the opinion that rolls can better serve as intermediate grinders preliminary to Chile and tube mills and probably work more cheaply than stamps. Chile mills do good work in some places and poor in others. They are not suited to very fine grinding. High-speed Chile mills, 4 to 6 ft. in diameter are more popular than low speed, 6 to 10 ft., which do their best work on coarse material and have a decided limit in their field of work. Pans are not generally considered as efficient as tube mills although sometimes used where low first cost is a controlling factor.

The ideas of Mr. Del Mar[2] are that for fine crushing for amalgamating and cyaniding, stamps or Chile mills are the best machines to follow the rock breaker. Stamps will take a coarser feed but Chile mills have a lower first cost which may be an important item where only small capital is available. Rolls and ball mills are applicable only in special cases. For fine grinding, Chile mills are good amalgamators, but are not suited to extreme fineness. Tube mills are the best, the cylindrical form being bette than the conical for sliming. However, pans do very good work especially if conditions are made right for them. The pulp should have between 1 1/2 and 4 parts of water to one of ore and the speed should be about 30 r.p.m. for amalgamating and 45 r.p.m. for grinding. Their low first cost offsets to some extent the disadvantage that they cannot grind to extreme fineness as readily as tube mills.

[1] *Eng. Min. Jour.*, XCVI, 821, 917 (1913).
[2] *Eng. Min. Jour.*, XCVI, 769 (1913).

The Hardinge system of breaker, rolls, Hardinge ball mill and Hardinge tube mill has its advocates who point to the simplicity and lightness of the plant especially if the rolls may be omitted as is the case on some ores. This system is comparatively new and consequently has to fight its way against the established methods.

The tendency in South Africa is to increase the ratio of tube mills to stamps and thus crush coarser in the stamps. The highest ratio is one tube mill to 10 stamps where each stamp crushes 21 1/2 tons in 24 hours; the lowest is one tube mill to 90 stamps. Several mills have one tube mill to 12, 16 or 20 stamps.[1]

The Kleinfontein mill, which has always held that stamps alone were better than stamps and tube mills, has recently installed four tube mills;[1] but the reason given is that increased capacity was desired and it was not practicable to add the additional stamps desired. It is claimed that the new stamp-tube mill combination costs more per ton milled and gives a lower extraction, but this is contrary to the experience in some of the other mills on the Rand.

Grinding Pans.—These appear to hold their own in their special field in the Kalgoorlie district.[3] In treating the Kalgoorlie telluride ores two main processes are used: the dry process which roasts all the ore, grinds and amalgamates it and treats it with cyanide and bromocyanide; the wet process which crushes, amalgamates and concentrates, the concentrates being roasted, ground and amalgamated and treated with cyanide and bromocyanide and the sands and slimes either cyanided and bromocyanided separately or the sands reground and treated with the slimes. The dry process costs more but it is simpler and gives higher recovery. For coarse grinding, stamps are used in the wet process and ball mills in the dry process; the pans are used as intermediate grinders in both processes, but for sliming, tube mills are considered preferable to pans. The following table shows the details of practice in the separate mills:

Name.	Method of General Reduction.
Associated.....	Ball mills and pans grinding roasted ore.
Assoc. Northern...	Ball mills and pans grinding roasted ore.
Boulder.....	Ball and Griffin mills and pans on roasted ore.
Kalgurlie.....	Ball mills and pans on roasted ore.
Perseverance.....	Ball mill and pans and tube mills on roasted ore.
South Kalgurlie...	Ball mills and pans on roasted ore.
Hainault.....	Stamps and pans grinding coarse pulp. No further grinding.
Ivanhoe.....	Stamps and pans grinding coarse pulp and tube mills for further reduction.
Lake View & Star.	Stamps and pans grinding coarse pulp and tube mills for complete reduction.
Horseshoe.....	Stamps and pans grinding coarse pulp and tube mills for complete reduction.
Oroya Links.....	Stamps and tube mills.
Hainault.....	Pans for grinding roasted concentrates.
Horseshoe.....	Pans for grinding roasted concentrates.
Ivanhoe.....	Pans for grinding roasted concentrates.
Lake View & Star.	Pans for grinding roasted concentrates.
Oroya Links.....	Pans for grinding roasted concentrates.

[1] *Met. Chem. Eng.*, XI, 536 (1913).
[2] R. Gascoyne, *Min. Eng. World*, XXXVIII, 1194 (1913).
[3] M. W. Von Bernewitz, *Min. Sci. Pr.*, CVI, 734 (1913).

The Forwood-Down type of pan is mostly used although there are some Middleton-Cobbe and some Freeman pans. The Forwood-Down pan has a classifying discharge, the pulp issuing from the pan through a row of 1-in. holes near the top of the pan. Bolted to the outside of the pan is the overflow lip which is in the form of a pocket having a slot at the bottom leading back into the pan. Heavy sand settles in the pocket and is returned through the slot while fine material flows over the outer edge of the pocket. The Freeman pan classifies by the use of centrifugal force. (See MINERAL INDUSTRY, Vol. XIX, p. 746.) Some mills use a hydraulic classifier separate from the pan and this probably gives more perfect classification. When used in stage grinding the usual ratio is one pan for five stamps. Some details of the pans are given in the following table, and further details of construction and operation may be found in the original article.

Name.	No. Used.	Size, ft.	Speed, r.p.m.	H.P.	Feed +150, Per cent.	Discharge −150, Per cent.	Screen Used.	Tons Daily.	Life of Shoes and Dies, Days.	Cost Per Ton, Cents.
Grinding roasted ore:										
Associated	20	5	50	5	47	85	27×27	9	120	40
Assoc. Northern	5	5	47	6	45	85	Various	7	180	40
Boulder	22	5	60	5	70	90	Various	7	180	24
Kalgurlie	16	5	56	8	47	80	27×27	11	140	40
Perseverance	14	8	30	11	54	80	30×30	11	140	40
South Kalgurlie	5	8	33	12	56	94	27×27	24	(Shoes 90) (Dies 120)	22
Grinding roasted concentrates:										
Hainault	2	5	48	5	29	94	27×27	24	150	22
Horseshoe	4	5	48	5	36	94	27×27	24	150	22
Ivanhoe	5	5	52	5	46	94	27×27	12	140	43
Lake View & Star	4	5	45	5	46	94	27×27	12	70	43
Oroya Links	4	5	45	5	46	94	27×27	12	70	43
Following stamps:										
Hainault	6	5	48	7	36	52	14×14	16	150	43
Ivanhoe	20	5	58	6	36	52	8×8	15	69	15 to 23
Lake View	15	5	60	9	39	60	8×8	13	50	20

From investigations of the grinding pan practice at the Great Fingall mine, Western Australia,[1] higher mechanical efficiency of grinding and less wear of iron per ton of ore were noted when corrugated shoes and dies were used because of the greater grinding surface obtained thereby. The corrugations took the form of concentric rings on 1 1/2-in. centers. Further, a speed of 58 r.p.m. gave better grinding results with lower consumption of power per pan than 58 to 60 r.p.m. With extremely hard shoes and dies a general tapering off of grinding efficiency was noted as the shoes and dies wore, while with shoes and dies of ordinary hardness the grinding efficiencies were approximately uniform during their whole life. By increasing the thickness of shoes and dies from 3 1/2 to 4 1/2

[1] E. Jensen, *Eng. Min. Jour.*, XCV, 952 (1913); *Met. Chem. Eng.*, XI, 291 (1913); from *Monthly Journal Chamber of Mines of Western Australia* (January, 1913).

in., the life was lengthened at a comparatively small increase in the cost of each set.

Economical fine grinding in pans has been discussed by M. G. F. Söhnlein and E. E. Wann.[1] A 5-ft. Allis-Chalmers combination pan regrinding tin ore in the form of middlings and tailings from Overstrom tables, had a capacity of 2.5 tons in 24 hours when running at 32 r.p.m. At 60 r.p.m. practically no grinding was accomplished. The pulp contained 20 per cent. solids. The quality of the work is shown by the following table:

	Feed, Per cent.	Discharge, Per cent.
On 40 mesh	2.0	....
Through 40 on 60 mesh	8.5	4.0
Through 60 on 80 mesh	24.4	8.2
Through 80 on 100 mesh	20.3	16.0
Through 100 on 150 mesh	26.0	23.4
Through 150 mesh	18.8	48.4

The height of the discharge did not appear to have any effect on the work.

By the introduction of a center feeding device which forced all the pulp to pass between the shoes and dies the speed could be increased to 60 r.p.m. and the capacity to 38 tons in 24 hours on pulp containing 48 per cent. solids. Following are sizing tests on this work:

	Feed, Per cent.	Final Product, Per cent.
On 40 mesh	20.0	....
Through 40 on 60 mesh	20.5	....
Through 60 on 80 mesh	16.5	1.2
Through 80 on 100 mesh	10.5	5.6
Through 100 on 150 mesh	8.5	4.5
Through 150 on 200 mesh	5.5	10.5
Through 200 mesh	18.5	78.2

There appears to be a critical speed corresponding to maximum efficiency. As the speed increases the quicker the shoes overtake the grains of sand which are moving outward in the shoe channels. On the other hand, increased speed means greater centrifugal force and the grains are thrown outward at such a speed that they escape without being ground. Cast-iron shoes and dies 1 1/2 in. thick wear at the rate of 0.67 lb. for each ton ground through 200 mesh. In the future these parts will be made 3 in. thick. The tonnage is 4.76 tons per 24 hours ground through 200 mesh for each horse power used.

In another case on pulp containing 15 per cent. solids the speed was reduced from 70 r.p.m. to 40 r.p.m., the central feeding device introduced and the muller weighted, and the effect was to increase capacity from 1/2 ton per hour up to 10 tons per hour.

Huntington Mills have not been able to hold their own against other grinding machines.[2] The great trouble is the high cost of upkeep and the

[1] *Eng. Min. Jour.*, XCVI, 581, 1183 (1913).
[2] C. T. Rice, *Eng. Min. Jour.*, XCVI, 215 (1913).

need of careful attention to keep them from wearing unevenly. Even feeding is a necessity for good work and the feed is best dewatered and fed to the mill by a special feeder. At the Silver King mill, Park City, Utah, the die ring is kept true by the frequent use of shoes which are in the form of soft cast-iron segments of a circle, of the same diameter as the inner diameter of the die ring, bolted to a yoke similar to the one carrying the muller. These shoes are longer than those regularly supplied by manufacturers and are perforated with holes at regular intervals. Quartz grains accumulate in these holes and cut away the die ring evenly and in about half the time required by the regular form of shoe.

Chile Mills.—Time lost for repairs by a Monadnock Chile mill in Nevada Wonder mill during a year was 3.66 days, while the time lost by 10 stamps was 7.70 days. This indicates that the claim that Chile mills lose more time than stamps is more apparent than real, because only part of a stamp mill may be shut down at a time while the whole mill stops when the Chile mill stops.[1]

The following table contains compiled data from users of Lane slow-speed Chile mills.[2] They mostly agree that the mill is an excellent amalgamator and a good fine grinder, and compares favorably with stamps when acting as an intermediate machine taking product from breakers and not grinding to extreme fineness.

Mill	*A*	*B*	*C*	*D*	*E*	*F*	*G*
Size of mill in feet	7	10	10	7	7	10	10
Time in actual operation, months	*H*	24	36	*I*	8	18	*J*
Capacity, tons in 24 hours	24	40	55	14	20	30	45
Horse power required	7	10	12	..	7	10	8
Gallons water used per minute	*K*	*L*	*M*	..	..	15	..
Height of discharge in inches	4	4	7	..	6	7	7½
Mesh of screen, if any	30	8	..	..	..	..	..
Character of ore	Medium	Hard	Soft	Hard	..	Hard	Medium
Mesh of discharged pulp	44	40	*N*	*O*	*P*	*Q*	*R*
Time shut down for repairs	*S*	*T*	2 hr.	..	..	..	...
Cost of repairs, cents per ton	5	5	*U*	..	3	5	4
Size of feed in inches	½	1	½	½	½	1	1

(A) In Arisona. Considers Lane better than stamps. Feeds direct from breaker to Lane mill. (B) In Southern Nevada. An excellent fine grinder and amalgamator. (C) In Idaho. An ideal amalgamator; 81 per cent. caught in the mill itself. (D) In California. Not satisfied. Grinds too fine. Capacity limited. (E) In Idaho. Better than stamps as a crusher. Less wear and less water needed. (F) In Nevada. Ore extremely hard; free milling; 80 per cent. of pulp through 60 mesh. (G) In Texas. An excellent machine for fine grinding. (H) Total crushed is 8500 tons. (I) 90 shifts to date. (J) 7000 tons to date. (K) 16,000 gallons in 24 hours. (L) Same as 10-stamp mill. (M) No record. (N) 90 per cent. is minus 100 mesh. (O) 80 per cent. is minus 100 mesh. (P) 95 per cent. is minus 100 mesh. (Q) 68 per cent. is minus 100 mesh. (R) 73 per cent. is minus 100 mesh. (S) 5 days per month. (T) Repairs made while cleaning up. (U) Lower than stamps.

Chile Mills Versus Hardinge Mills.—One and one-half years operation of Hardinge and Chile mills at the Miami mill has shown the former to be superior.[3] The Hardinge mill is 8 ft. in diameter with cylinder 22 in,

[1] H. A. Megraw, *Eng. Min. Jour.*, XCV, 693 (1913).
[2] E. J. Schrader, *Min. Sci. Pr.*, CVII, 136 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 274 (1913).
[3] R. Franke, *Am. Inst. Min. Eng. Bull.* No. 79, 1201 (July, 1913); No. 83, 2702 (Nov.); *Min. Sci. Pr.* CVII, 223 (1913); *Min. Sci.*, LXVIII, 227 (1913); *Eng. Min. Jour.*, XCVI, 493 (1913); *Min., Mag.*, IX, 222 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 216 (1913).

long. The Chile mill is a fast running 3-roller, 6-ft. Saturn mill with 0.037-in. screens. The feed is moderately hard and is the oversize of 0.029-in. Callow screens which follow rolls crushing to 0.5 in. The Hardinge mill is more steady in operation and requires less attendance. Delays amount to 2.11 per cent. of the total time for the Chile mill and 1.29 per cent. for the Hardinge. The Hardinge requires less power, 9.6 h.p. hour per ton fed against 10.7 for the Chile. It also delivers more of the desired product, between 60 and 200 mesh, as shown by the following sizing tests:

	Chile Mill.		Hardinge Mill.	
	Feed. Per cent.	Product. Per cent.	Feed. Per cent.	Product. Per cent.
+ 10 mesh	61.4	0	60.2	0
− 10+ 20 mesh	22.9	2.3	26.8	0.2
− 20+ 40 mesh	6.1	18.5	5.8	8.1
− 40+ 60 mesh	1.0	11.4	0.8	13.8
− 60+100 mesh	0.9	12.1	0.7	19.0
−100+200 mesh	1.2	13.5	0.8	18.0
−200 mesh sand	1.2	10.6	0.8	10.0
−200 mesh slime	5.3	31.6	4.1	30.9

The detailed maintenance costs for the Chile mill figure out 5.066 cents per ton and for the Hardinge 4.545 cents per ton and the depreciation costs are estimated at 3 cents and 0.5 cents per ton respectively. Detailed calculation of mechanical efficiency of crushing shows 23.45 per cent. in favor of the Hardinge. A test on a Hardinge mill 6 ft. diameter showed that by increasing the length of the cylinder from 22 to 38 in. the capacity was doubled, the power consumption lessened and the pebble cost reduced to nearly one-half.

Tube Mills.—The dimensions of a tube mill should be adjusted to the work to be done.[1] A diameter of 48 in. inside the liners is satisfactory for regrinding stamp mill amalgamation tailings (30 mesh), but when the feed is a coarse roll or stamp product through 6 mesh the diameter should be at least 54 in. Similarly for all sliming for cyaniding, lengths up to 22 ft. are used, but for concentrating the length may be only 13 ft. A 1/4-in. roll crushed feed requires about 2 ft. greater length of tube than a 6-mesh stamp product. Owing to increased pebble loads and use of ribbed liners Davidsen's rule that horse power is 0.15 times contents in cubic feet, no longer holds and a safer rule is 0.25 times cubic contents calculated by adding 2 in. to internal diameter when new; 50 to 60 per cent. of the volume is to be occupied by pebble load; the moisture in the feed is 38 to 40 per cent. and the peripheral velocity of the mill 360 to 400 feet per minute. The best speed is determined by running the mill

[1] A. M. Merton, *Min. Eng. World*, XXXVIII, 1129 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 22 (1913).

at various speeds and measuring the power. That speed which requires the greatest power per revolution is the most efficient.

A table has been published showing weights of pebbles necessary to fill tube mills of various diameters to various heights. The basis is that a cubic foot of pebbles weighs 105 lb.[1]

The standard South African tube mill has been 22 ft. long and 5 ft. diameter, but it has been found that a mill 16 1/2×6 ft. does practically the same work and consumes 35 per cent. less power. Experiments now going on indicate that they may be shortened still more with economy.[2]

At Tonopah, Nevada, the tendency toward short tube mills is well shown.[3] The Montana Tonopah mill which is one of the older mills still uses 22×5-ft. tube mills. The West End and Tonopah Extension have 18-ft. mills and the new MacNamara has 16 ft. The last named claims that the short mill gives the same results as far as fineness of output is concerned with less wear of lining and pebbles and less power consumption.

At Tonopah, contrary to the results elsewhere, ribbed tube mill liners are claimed to have proved inferior to smooth liners. The West End mill claims that a hard smooth iron liner is best and other mills use smooth silex. In theory a smooth lining would appear to be inefficient in that it allows the pebbles to slide. It is possible, however, that the elements of speed of rotation of the mill or of the character of the ore at Tonopah may cause the millmen to be right in their claims even though millmen in other districts have proved the opposite.

Among tube mill liners used in South Africa are: (1) blocks of hard local flint 4 to 6 in. thick; (2) the Osborn liner consisting of longitudinal iron bars; (3) concrete blocks with protruding pins of old bolts, drill steel, etc.

Ribbed manganese steel liners at the Morro Velho mill, Brazil, are estimated to have a life of 952 days at a cost of $0.94 per day against 289 days for chilled iron at a cost of $1.82 per day. The manganese ribs retain their shape better and hold the pebbles more securely between them, thus lessening the wear of metal.[4]

The Forbes[5] tube mill liner used at El Tigre mill consists merely of grating plates of chilled iron or manganese steel which are backed by mild steel plates 3/16 in. thick. The backing pieces do not have to be thrown away when the gratings are worn out.

[1] W. A. Caldecott, *Jour. Chem., Met. Min. Soc. So. Afr.*, XIII, 363 (1913); *Min. Sci. Pr.*, CVI, 866 (1913); *Met. Chem. Eng.*, XI, 417 (1913).
[2] *Min. Eng. World*, XXXIX, 974 (1913); *Min. Mag.*, IX, 224 (1913); *Mex. Min. Jour.*, XVII, 497 (1913); from *So. Afr. Min. Jour.*, July 26 and Aug. 2, 1913.
[3] H. A. Megraw, *Eng. Min. Jour.*, XCV, 413, 503 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 29 (1913); *Min. Sci.*, LXVII, 211 (1913).
[4] *Min. Sci. Pr.*, CVII, 423 (1913).
[5] D. L. Forbes, *Mex. Min. Jour.*, XVI, 186 (1913).

Many mill men recognize the increased efficiency in tube milling obtained by feeding mixed coarse and medium material. At the Black Oak mill, California, one tube mill receives sands from 15 stamps with 19-mesh screens and from 5 stamps with 6-mesh screens. The Tonopah Extension mill at Tonopah uses 3-mesh and 12-mesh stamp screens for the same purpose.

By increasing the pebble load in the two 5 by 18-ft. tube mills of the West End mill at Tonopah from a point slightly below the center of the mill to 6 in. above the center, the capacity of the plant was increased from 100 to 150 tons per day. The power required by the two tube mills increased from 100 to 125 h.p. at the same time. The increased capacity of the two tube mills allowed the use of a coarser battery screen.[1]

Hardinge Mills.—H. W. Hardinge[2] has discussed the development of the conical ball and pebble mills. Inclining the axis downward toward the discharge may be used to increase the discharge. More feed water causes less slimes. Larger diameters cause more slimes. A peripheral speed of 750 ft. per minute is about correct for a mill 8 ft. in diameter. Horse power used by these mills is approximately as follows:

	Horse power
4.5 ft. ball mill	10 to 15
6 ft. by 22 in. granulating pebble mill	15 to 18
6 ft. by 72 in. sliming pebble mill	25 to 30
8 ft. by 22 in. granulating pebble mill	30 to 35

An interesting change of a 7 by 12-ft. tube mill into a conical mill has been made in the Morning Mill, Idaho.[3] Timbers were first bolted inside to form the proper cone and inside of these steel rails were bolted to form a ribbed lining. Capacity was reduced by the change from 98.64 tons per day to 88.2 tons and the horse power from 75.6 to 65. The speed was 22 1/4 r.p.m. before and after. The product was a little coarser after the change.

	Before. Per cent.	After. Per cent.
On 100 mesh	16.5	25.45
Through 100 on 150 mesh	5.5	17.20
Through 150 on 200 mesh	20.5	16.00
Through 200 mesh	57.5	41.20

The experiment of lining an 8 ft. by 22 in. Hardinge mill in the mill of the Arizona Copper Company, with flint pebbles instead of silex blocks has given very satisfactory results.[4] Pebbles last at least 4 months against 75 days for silex blocks. The pebbles also make a rough surface to prevent slippage and thus avoid the use of lifters. The pebbles are set on end tight together and imbedded in cement for about two-thirds of their height. The larger pebbles are used in the cylindrical

[1] H. A. Megraw, *Eng. Min. Jour.*, XCV, 413 (1913).
[2] *Am. Inst. Min. Eng., Bull.* 75, 453 (March, 1913).
[3] *Eng. Min. Jour.*, XCVI, 977 (1913); *Met. Chem. Eng.*, XI, 423 (1913).
[4] D. Cole, *Eng. Min. Jour.*, XCVI, 927 (1913).

part of the mill, in the short cone and in the larger part of the long cone and successively smaller ones in the remainder of the long cone.

Theory of Crushing.—A. O. Gates[1] has shown that from his tests and calculations, Kick's law—that energy consumed in crushing is proportional to volumes—does not hold, and the correct theory is that of Rittinger—that force required is proportional to surface produced. On this theory then it is clear that the surface produced on equal masses of volumes of rock is proportional to the reciprocals of the diameters or, for approximate work, to the screen size expressed in meshes per linear inch. For a lot of given sized particles the energy used is proportional to the product of their

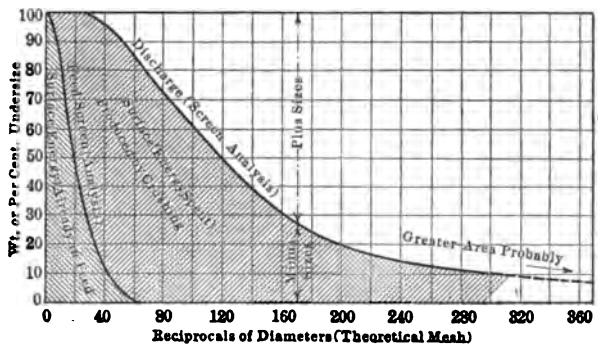


FIG. 1.—Crushing Surface Diagram.

surface by their weight, which can be shown graphically by an area. And if a series of these areas are placed side by side representing the summation of the energies of the different sizes produced by a crushing operation the total area is proportional to the energy expended on the rock. And when the cumulative weights of the different sizes are plotted consecutively, as shown in the figure, the area between the sizing analysis curve and the zero line is proportional to the work expended on the rock in breaking it down from an infinite mass. And then if further crushing takes place on all or part of this rock and the new sizing analysis is plotted, the area between the two curves is proportional to the further work done. This is the crushing surface diagram.

Gates' tests indicate that for accuracy of results obtained by the use of this diagram, it is necessary to consider the weights of particles much finer than 200 mesh which is usually the limit of test sieves.

A. F. Taggart[2] has made a detailed mathematical analysis of the work of Gates and others, both for and against the Rittinger theory, and

[1] *Eng. Min. Jour.*, XCV, 1039 (1913); *Jour. Chem., Met. Min. Soc. So. Afr.*, XIV, 91 (1913).
[2] *Am. Inst. Min. Eng., Bull.* 85, 143 (January, 1914).

reaches the conclusion that Kick's law is the proper fundamental basis for computing the efficiencies of crushing operations.

Screening and Classifying

Screening Tests.—The specifications of the standard testing 100-mesh cement sieve (0.0055 in.), 200-mesh cement sieve (0.0029 in.), 20-mesh sand sieve (0.0335 in.), and 30-mesh sand sieve (0.0223 in.), have been given by the U. S. Bureau of Standards, who will also for a fixed fee examine and certify screens.[1]

Some light on the practical application of Stadler's "ordinal numbers"[2] as obtained from screen analyses has been given by J. W. Bell.[3] The "ordinal number" N of a particle of Volume V or of a screen of known aperture can be obtained by the formula $N = \frac{\log \frac{1}{V}}{\log 2}$. If a product is screened and the percentage of each size determined and multiplied by its "ordinal number," then the sum of these results give the composite "ordinal number" of the original product. Taking the published results

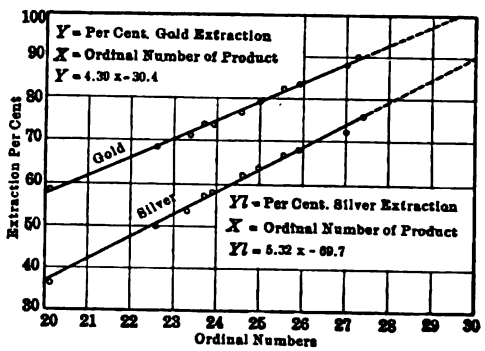


Fig. 2.—Extraction Curve.

of screen analyses and extractions at the El Oro mill, Mr. Bell has found that in this case the "ordinal numbers" are proportional to the extractions and on plots from straight lines of the formulæ

$$Y = 4.39\,X - 30.4 \text{ for gold}$$
$$\text{and } Y\,1 = 5.32\,X - 69.7 \text{ for silver}$$

This is well shown in Fig. 2.

Whether this will be true on other ores will be found only on investigation. Results are promised on Rand gold ores.

[1] *Circular No.* 39, U. S. Bureau of Standards.
[2] *Inst. Min. Met.*, XIX, 471 (1910).
[3] *Can. Min. Inst.*, XVI, 137 (1913); *Eng. Min. Jour.*, XCV, 1044 (1913); *Min. Sci.*, LXVII, 207 (1913); *Jour. Chem., Met. Min. Soc. So. Afr.*, XIV, 211 (1913).

The "ordinal number" extractions shown on the plot check very well with the "sand indices" calculated by Caetani and Burt[1] but the extraction does not sum up proportional to the increase of surface exposed.

The simplification realized by being able to represent the results of a complex screen analysis by a number permits the use of simple charts to show the variations in the size of mill products and the resulting increases or decreases in extraction and also to show the efficiencies of screens, classifiers, or other machines under different adjustments. Sometimes screen analyses alone may be misleading because screen analyses of two products may appear entirely different yet when their "ordinal numbers" are calculated they are found to be practically alike.

Settling Tests.—H. Stadler[2] reports some interesting results of elutriation tests on Rand ore which indicate that this method may be used to supplement at the fine end grading analyses obtained by screening. The apparatus used was the well-known Schoene apparatus which has had extensive application in the past in work on clays and fine soils. His results are in concordance with those of Richards[3] obtained by means of free settling tubes. Incidentally he discusses the theory of free settling and the application of the laws of eddying resistance and of viscous resistance.

Classifiers.—The Argall Ovoca classifier[4] used at Stratton's Independence mill is of the mechanical type. It uses either one spiral conveyor or two spirals rotating in opposite directions. It is fed at *G* (see Fig. 3), and the sand is carried up the incline while the fine material is washed down into the settling tank *B* and overflows the circular weir *F*. A dam *C* serves to lengthen or shorten this weir and thus decrease or increase respectively the fineness of the particles in the overflow. The speed of the spirals is three to eight revolutions per minute; the slower the speed the coarser is the sand discharge. A small space is left between the spiral and the bottom of the trough *D*. Also angle irons *A* of relatively short height are placed just outside of the edges of the conveyors to constitute with the side walls of the trough overflow channels to carry fine particles back into the settling tank *B*.

By the use of a cock which is opened intermittently by a mechanical device, a 5-ft. cone classifier at the Arianeña mill at Guanacevi is able to deliver a very thick spigot discharge for the tube mill. This spigot has no trouble in clearing itself, even if by any chance the whole cone becomes filled with sand.[5]

[1] *Am. Inst. Min. Eng.*, XXXVII.
[2] *Inst. Min. Met.*, XXII, 686 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 85 (1913).
[3] *Ore Dressing*, III, p. 1423.
[4] *Eng. Min. Jour.*, XCV, 21 (1913); *Min. Mag.*, VIII, 141, (1913); *Met. Chem. Eng.*, XI, 159 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 630 (1913).
[5] E. F. Ayton, *Mex. Min. Jour.*, XVI, 87 (1913).

The Boston and Montana or Great Falls system of indirect classification which has been developed for the Washoe mill at Anaconda has given splendid results. In this system the pulp is first given a preliminary classification for removal of slimes and the residue or spigot material is passed along to a second classifier for a further division. For the exact flow sheet of this practice the reader is referred to "examples of milling practice" given later in this review.

The patented classifier used is of the hindered settling type and is called the Anaconda classifier. Its development and full details of its work in treating various sizes of pulp are exhaustively discussed in a paper by Robert Ammon.[1]

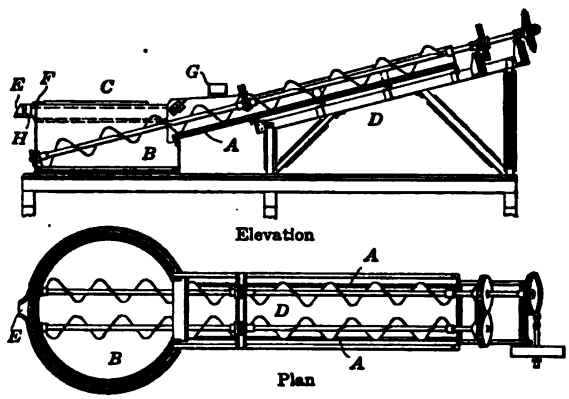


FIG. 3.—Argall Spiral Classifier.

The nature of this paper is such that it is impossible to reduce to a brief space the data in the way of sizing tests, tonnages, computations, etc., which it contains and the reader is therefore referred to the original article for the complete story. The two types in use are called the preliminary or desliming classifier and the table feed classifier. Both are conical tanks with central feed and peripheral overflow. The desliming type is 7 ft. diameter and either has one constriction 6 in. diameter and 2 in. long with a ratio of 3.9 to 1, or has constriction consisting of several small pipes with a ratio of teeter chamber area to constriction area of 4.6 to 1. The only hydraulic water used is that necessary to supply the spigot and amounts to 50,000 to 90,000 gal. per 24 hours. The feed may amount to as much as 250,000 gal. of pulp per 24 hours with 200 tons of solids and the overflow will contain not over 2 per cent. coarser than 200 mesh. It will do uniform work even though the rate of feed is constantly changing. The spigot is clear and very dense. One advantage of using a

[1] *Am. Inst. Min. Eng., Bull.* No. 80, 2151 (August, 1913).

preliminary desliming classifier is that the overflow slime is 1.6 to 2 times as dense as in the ordinary system of classification where the slime overflow contains all the hydraulic water which has been added to produce rising currents for the coarser products.

The table feed classifiers vary somewhat in their dimensions but the general type is shown in the Fig. 4.

Section of Table Feed Classifier

Area top of annular space	269.4	sq. in.
Area bottom of annular space	163.4	sq. in.
Area of teeter chamber	78.8	sq. in.
Area of constriction opening	33.46	sq. in.

The inner feed cone has been found to be a very important essential. A classifier of this type can treat from 150 to 350 tons of solids in 24 hours using 450 to 900 gal. of water per ton of feed, and not allowing any deterioration in the quality of its work when sudden variations occur in the rate of feed. The velocity at the top of the annular space is figured to be the same as the free settling velocity of the maximum quartz grain to be lifted into the overflow; the velocity at the bottom of the feed cone is 25 per cent. greater. These classifiers have been found to yield products which give splendid separations on Wilfley tables.

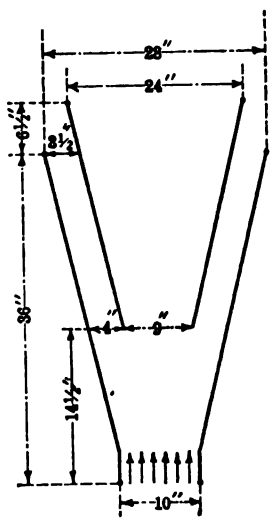


FIG. 4.—Section of Table Feed Classifier.

The action of the Richards hindered settling classifier[1] and especially of the above-mentioned Anaconda type with its constrictions and teeter chambers has been studied at the Boston and Montana mill by E. S. Bardwell.[2] For fine material he finds that a perforated plate or diaphragm is the best form of constriction but for coarse work where grains 0.75 mm. or larger are to be lifted the best constriction consists of a plate in which a series of short tubes or pipes have been inserted.

Under conditions of equilibrium the classifier may be considered to have become bedded, that is, the teeter chamber is full of particles in quicksand condition and these particles are neither light enough to pass into the overflow nor heavy enough to fall through the constriction. Addition of more particles upsets this equilibrium by increasing the density of the mass, and if some of the added particles are heavy enough they will pass down through the constriction or will force some of the lighter particles into the overflow.

[1] Richards, *Ore Dressing*, III, Chapters XXXII and XXXIII.
[2] *Am. Inst. Min. Eng., Bull.* No. 80, 1469 (Aug., 1913.)

Observations of classifiers under operating conditions have shown that for each size of grain there is a certain density that can be maintained in the teeter chamber and that the ratio existing between the area of the sorting column and the area of the constriction depends primarily on this density. If the ratio is too large, in the case of open spigot classifiers the capacity of the classifier is reduced and banks tend to form; if it is too small the bed disappears and free settling conditions result. Maximum capacity is obtained by using a ratio which will give a teetering column of maximum permissible density. This condition is called "full teeter." The density at full teeter varies, being greater for coarse particles than for fine. Some experiments to determine this variation were made and the results are given in the table:

Diameter in mm.	Density at Full Teeter: Grams per Gallon.	Ratio Water to Sand by Volume.	Diameter in mm.	Density at Full Teeter: Grams per Gallon.	Ratio Water to Sand by Volume.
2.19	4618	1.07	0.60	2763	2.97
1.84	4489	1.27	0.50	2311	3.06
1.54	4239	1.49	0.42	2573	3.73
1.20	3989	1.80	0.35	1937	4.20
0.92	3747	2.18	0.26	1684	5.00
0.841	3000	2.34	0.166	1333	6.51
0.77	3353	2.49	0.070	866	10.57

The relation between diameters and densities at full teeter, which has been found by trial to hold most nearly true, is that the densities vary inversely as the square root of the surface exposed in 1 g. of particles of each of the given sizes.

On the assumption that at full teeter the area occupied by water is to the area occupied by sand as the area of the sorting column is to the area of the constriction, the ratios given in the table become directly applicable to the design of hindered settling classifiers and for practical use a curve has been prepared as shown in the figure.

These ratios may also be computed from the formula $R = \frac{K}{\sqrt{D}} - 1$ where R is the ratio, D is the diameter and K is a constant approximately equal to 3. To take a specific case of a 4-spigot classifier delivering 2 to 1.25 mm. quartz in the first spigot, 1.25 to 0.75 in the second, 0.75 to 0.35 in the third and 0.35 to 0.10 in the fourth the ratios should be 1.8, 2.6, 4.2, and 8.9 respectively.

Bardwell also works out the design of a classifier for a specific case, following in a general way the method used by Richards.[1] He emphasizes the point that to do its best work a classifier should be especially designed to meet the conditions under which it is to operate.

[1] *Ore Dressing*, III, Chapter XXXII.

Slime Settling.—At the Nevada Consolidated mill Dorr mechanical thickeners have been installed inside the plant for settling slimes and outside for clarifying the water.

At the Butte and Superior mill the fine zinc concentrates produced by flotation are treated in Kelly filters to eliminate the greater part of the water.

For clarifying water from slime at the Bergwerkswohlfahrt mill near Clausthal, filtering launders are used in which the slimy water rises through a bed 16 in. thick of pyrite and slag also the settling ponds have porous filtering sides of pyrite and slag, and finally magnesium chloride is used as a precipitant.[1]

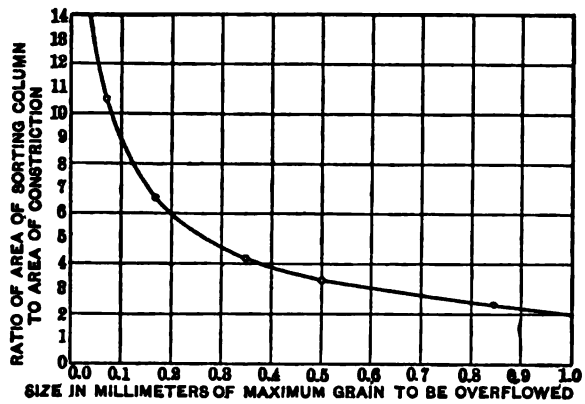


FIG. 5.—Hindered Settling Classifier Curve.

Milling in the Joplin district of Missouri has been improved by the use of settling ponds for the recovery and treatment of slimes which formerly went to waste.[2] The water leaving the mill of the American Zinc, Lead and Smelting Co., at Webb City, goes through three settling tanks the sediment from which is treated on a series of tables in the first sludge mill. The overflow of these tanks goes to 10 new tanks and although apparently free from metallic sulphides when leaving the first set of tanks, enough sediment is caught to yield 3000 lb. of galena and 6000 lb. of blende concentrates per week when treated on James tables.

In connection with the treatment of slimes at Anaconda, Montana,[3] a study has been made of settling devices. It has been found that even on the same ore different treatments will produce slimes of different characteristics and rates of settling. The Anaconda slime consists of the

[1] *Metall und Erz*, X, 429 (1913).
[2] L. L. Wittich, *Eng. Min. Jour.*, XCV, 474 (1913).
[3] Ralph Hayden, *Am. Inst. Min. Eng., Bull.* No. 80, 1443 (August, 1913).

overflow of settling tanks following hydraulic classifiers and also the head water of the tables. Analyses over long periods show uniform composition of this slime, but it is noteworthy that it contains 18 to 22 per cent. alumina against 9 per cent. in the original ore. Physical analyses by repeated dilution and elutriation has been used to separate the slime into sands of different setting powers and colloids. The following table shows the results of such analyses:

Velocity of Settling per Second, mm.	Diameter of Quarts of this Velocity, mm.	Solids, Per cent.	Copper.	
			Assay, Per cent.	Per cent.
+10.16	+0.146	0.6	1.40	0.4
−10.16 + 5.08	−0.146+0.106	1.2	1.96	1.1
− 5.08 + 2.54	−0.106+0.074	3.1	2.54	3.5
− 2.54 + 1.27	−0.074+0.046	7.3	3.05	10.0
− 1.27 + 0.635	−0.046+0.029	11.1	3.46	17.2
− 0.635+ 0.318	−0.029+0.017	24.0	2.94	31.4
− 0.318+ 0.159	−0.017+0.009	17.1	1.96	15.0
− 0.159+ 0.000	−0.009	0.4	0.86	0.1
Total sand		64.8	2.72	78.7
Primary colloid		33.0	1.47	20.3
Secondary colloid		2.2	1.13	1.0

Chemical analysis of colloids is given in the following table:

	Free Water, Per cent.	Ignition Loss, Per cent.	SiO_2, Per cent.	Fe, Per cent.	S, Per cent.	Al_2O_3, Per cent.	CaO, Per cent.	Cu, Per cent.
Primary colloid	0.46	8.08	52.5	1.7	2.3	24.8	0.9	1.47
Secondary colloid	0.43	5.18	58.1	1.3	1.7	25.4	0.9	1.13

Settlers in use or on trial for these slimes are as follows:

(1) Slime ponds, six in number, each 300 × 600 × 15 1/2 ft., operated in cycles, settle well but it is hard to recover slime at proper density.

(2) Open tanks, either rectangular or circular, have either central feed and peripheral overflow or pulp flows across from end to end or side to side. A tank 10 ft. 10 in. by 9 1/2 ft. by 8 ft. deep, when fed with slime of 2.5 per cent. solids, recovered 100 per cent. of the feed solids in the spigot when fed at the rate of 20 gal. per minute or 70 per cent. at 38 gal. per minute.

(3) Baffle retangular tanks with corrugated iron baffles inclined 45 degrees showed little if any advantage over open tanks if perfect settling is desired, but if it is desired to slough off a portion of the solids the baffle tank has considerable greater capacity.

(4) Callow tanks, 8 ft. diameter, at Anaconda receive 11 to 24 gal.

slime per minute of about 2 per cent. density and deliver 90 to 95 per cent. of the total solids into the spigot.

(5) The Kuchs-Laist centrifugal separator is compact but has mechanical difficulties.

(6) The Garred filter probably treats 1000 gal. of pulp per minute and gives perfect separation of solids.

(7) The Dorr continuous thickener is compact and efficient but has high maintenance costs and operates in cycles. Its capacity is 0.20 to 0.25 gal. per minute per square foot of area which is about the same as (2) and (4). More recent designs of this apparatus have as many as four shallow tanks superimposed one above the other thus obtaining great increase of capacity.

Baffle tanks have not given satisfactory results elsewhere. H. N. Spicer[1] reports that the baffle tank reported by Gardiner[2] to be doing good work in Australia has been discarded owing to the fact that slime built up on the baffles and slid off in the form of a cake. Similarly in South Africa trials of such tanks are reported to have been unsatisfactory.

Theory of Slimes and Their Settlement.—Definitions of sand, slime and colloids in ore dressing, together with a discussion of settling in water, have been contributed by G. Caetani.[3] He makes a primary division between crystalline material and colloids. The former is granular, has no chemical affinity for water and no solubility in water and includes: (1) Coarse sand down to 100 mesh, which settles in running water; (2) fine sand which settles in still water and can be concentrated on a Wilfley table, and usually lies between 100 and 250 mesh; (3) fines which still show crystalline character and may remain in suspension a long time and which merge into colloids at the fine end. Slime is a mixture of fines and colloids, although this term is usually applied in mill practice to material finer than 200 mesh.

Colloids are amorphous substances of gelatinous nature which have a well marked chemical affinity. The "sol" form is soluble in water forming a turbid suspension. It can be changed by the addition of chemicals to the "gel" form which is thus precipitated. Colloids carry an electrostatic charge, usually negative, which hinders settling. Electrolytes usually decrease the charge and cause flocculation or coagulation and subsequent settling, although in certain cases an excess of electrolyte will hinder settling, probably owing to the increase viscosity and specific gravity of the liquid due to the electrolyte. Anything which decreases

[1] *Min. Sci. Pr.*, CVI, 954 (1913), CVII, 194, 429 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 219 (1913).
[2] MINERAL INDUSTRY, XX, 821.
[3] *Min. Sci. Pr.*, CVI, 438 (1913); *Min. Mag.*, VIII, 379 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 83 (1913).

the viscosity of the liquid, for example increased temperature, will accelerate settling. In one instance Ashley showed that the rate of settling was a linear function of the temperature. The rate of settling is faster where the floccules are large and considerable distances apart than where they are small and close together so that the water finds difficulty in filtering up through them. Some colloids will settle to a compact mass like clay, while others will settle to only a thin consistency and then stop. In ore-dressing practice it is not economically possible to separate crystalline matter and colloid. Owing to differences in colloids of various ores the best electrolyte can best be determined by experiment and only those which are cheap and effective when used in small quantities can be employed.

Mill slime when held in suspension must be considered to form a liquid of higher specific gravity and viscosity than water, and as such will effect the settlement of coarse sand and the flow of pulp in launders and the separation on tables. For example, with very colloidal ores coarse sand will be carried along in classifiers and deposited in the finer spigots. This shows an argument for removal of slime as the first step in classification. In launders, slime has a beneficial effect in helping to keep sand on the move and thus prevent banking and clogging. On the other hand slime may deposit accretions which are not easily removed by fast running water.

Colloids are produced mainly from the decomposition of feldspar silicates and other minerals in the ore and are not created appreciably by the comminution of the ore, except in so far as this comminution liberates the colloids. For this reason the original mill slime which may be colloidal should be settled and treated separately from the slime obtained by regrinding which will more likely be of crystalline character.

Under fixed conditions of dilution, temperature and percentage of electrolyte, a slime will settle at a certain well-defined rate which rate will decrease as the slime in settling becomes thicker. The supernatant liquor or overflow will be turbid if "sol" colloids are present or clear if "gel" colloids are present. The volume of pulp that can be fed to a settling tank therefore must be equal to that corresponding to the settling of the slimes surface plus the volume of thickened pulp discharged through the spigot. This shows that the capacity of a settling tank cannot be increased by increasing the length of the overflow except in so far as this lengthening serves to prevent local increase of velocities toward the overflow. It is best to keep the level of the slime at some distance below the overflow level. A deep tank will settle slime more rapidly than a shallow tank.

The colloids govern the rate of settling in a tank; the consistency of

the discharge is governed by the proportion of quick settling material and of colloid at its maximum degree of consistence. The colloid forms the liquid (or moisture) of the spigot discharge. Deep tanks deliver a thicker discharge than shallow because the weight of the particles of crystalline matter serves to compact the spongy mass of packed colloid floccules.

In grinding or in concentrating, the presence of colloids serves to increase viscosity of liquid and thus tends to hold sand in suspension. For this reason a Wilfley table or a vanner will do better work on a thin pulp or on a pulp from which the colloid has been removed, than on a thick pulp containing colloids.

In a paper on slime settlement W. Shellshear[1] first discusses the various factors that have been considered to affect the settlement of slime and then records the results of his own experiments to prove the truth of previous theories. He used various minerals that were selected for their purity. Each mineral was crushed extremely fine in an agate mortar. Distilled water was used to make the suspensions and some reagents were added to determine their effect on the rate of settlement. An examination of the settling rates of the different minerals showed that they could be divided into three classes according to the time required for the settlement in pure water. Those requiring from 7 to 8 hours to a week were classified as slow settling; those settling in 4 to 7 hours intermediate settling; and those requiring only 1 1/2 to 3 hours fast settling. In all cases 2 grm. of mineral were suspended in 100 c.c. of distilled water and allowed to settle until the water was clear.

Class A Slow		Class B Intermediate		Class C Fast	
Tin oxide	4–7 days	Copper pyrite	4–5 hours	Zinc blende	3–4 hours.
Wolframite	4–7 days	Bornite	4–5 hours	Calcite	2–3 hours.
Feldspar	3–4 days	Molybdenite	4–5 hours	Garnet	2–3 hours.
Steatite	20–30 hours	Quarts	7–9 hours	Iron pyrite	3–4 hours.
Kaolin	....			Magnetite	2–3 hours.
Mica schist	30–50 hours			Stibnite	3½ hours.
Rhodonite	2–4 days			Galena	3 hours.
Scheelite	3–4 days			Fluorspar	2–3 hours.

Investigation was made of the effect of different minerals on each other with the following general deductions. Those of Class A have no effect on the settling of each other, those of Class B have no effect on the settling of each other; those of Class C will settle those of Class A if present in sufficient quantity; those of Class C increase the time of settlement of those of Class B; Class B will not settle Class A but will either be held up or settle leaving Class A in suspension.

It will be observed in the table that the sulphides are in Class B and C; also that three of the minerals of the slow settling Class A are of high

[1] *Proc. Australasian Inst. Min. Eng.*, Dec., 1912. *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 634 (1913). *Met. Chem. Eng.*, XI, 349 (1913).

specific gravity; tin oxide, wolframite and scheelite. Again calcite, a mineral of low specific gravity is one of the most rapid settling minerals of Class C. Curves are given which show that for mixtures of two minerals of the different classes, there is a definite ratio at which the settlement is most rapid; also that the effect of dilution on settlement varies with the different classes. Thus, with Class A, the greater the dilution the greater the settlement as shown by tin oxide. With Classes B and C and with mixtures of C and A (provided the Class A mineral is not present in sufficient excess to change the mixture into a slow settling one) the dilution does not affect the rate of settlement. In testing the action of electrolytes he found that 2 c.c. of one-tenth normal sulphuric acid per 100 c.c. of water hastened the settlement in all classes. Calcium chloride had a similar effect, but was especially rapid on suspensions of siliceous matter. Lime had an action similar to that of calcium chloride. Caustic soda in small quantities (1 c.c. of one-tenth normal solution per 100 c.c. of water) caused siliceous slime to remain in suspension; in large quantities, however, it acted similarly to the electrolytes. Alum and sodium carbonate settled all classes of slime by forming precipitate. Potassium permanganate settled slime with great rapidity while tannic acid kept all suspensions in a dense mass depending on the strength of the solution. After continued agitation, however, the suspension suddenly settled rapidly.

Hand Sorting, Jigs and Tables

Ore Sorting.—The decision to abolish ore sorting at the Knights Deep mill[1] has renewed the discussion on this subject on the Rand. Although it is generally held that sorting pays on Rand ores, in the case of the Knights Deep ore which is low grade the management has satisfied itself that it is cheaper to mill than to sort. In general as the grade of the ore decreases on the Rand, the amount of waste sorted out decreases at the same time. The economy of sorting is always a function of the labor cost and in some districts with low priced labor, sorting pays where in other districts high priced labor makes it prohibitive.

At the Crown Mines ore sorting plant[2] the sorting belts are operated on a non-continuous system. They move forward until a lot of unpicked ore is presented to the pickers who remove the waste, and the belts are moved forward again until the residue on the belt has passed the last picker and then stopped again thus presenting another lot of unpicked ore to the pickers and so on.

[1] *So. Afr. Min. Jour.*, Nov. 30 and Dec. 7, 1913. *Eng. Min. Jour.*, XCV, 182 (1913). *Min. Mag.*, VIII, 40, 66 (1913).
[2] R. C. Warriner, *Min. Sci. Pr.*, CVII, 13 (1913). From South African Association of Engineers.

At the Bunker Hill & Sullivan Mine, Idaho, detailed investigations have shown that sorting of the lead ore of that district is not as economical as crushing and concentrating. Even jigging the oversize of 30-mm. screen is cheaper and as efficient as hand sorting and the economic recovery from sorting coarse material is much lower than from crushing, sizing and concentrating it.[1]

At Tonopah, Nevada, most of the mills remove the waste from the silver ore in a more or less systematic manner.[2] At the West End mill the ore is first treated in a wash trommel which screens and thoroughly washes the ore in hot water and delivers it to one-half of a picking belt. Waste is moved to the clean half of the belt by the pickers and thus when the belt passes over its end pulley a divider sends the waste to waste bin and the ore to mill bin.

Jigs.—Tests of Richards pulsator jig on retreatment of black sand and dredge gravel have shown a practically complete saving of both coarse and fine gold. These jigs with their high capacity and compactness would seem to be especially adapted to gold dredging work.[3]

Wilfley Tables.—Active litigation still continues on the part of the manufacturers of the Wilfley table against other makes of riffle tables which are claimed to infringe the Wilfley patent and already several decisions have been made in favor of the Wilfley people.

Tables for Handling Slime.—The evolution of the round table has been discussed by T. Simmons[4] serving as a preliminary paper to that of Hayden[5] on the treatment of slimes at Anaconda, Montana. The character of these slimes has been previously discussed. Tests were made simultaneously on round tables 18 ft. diameter, on Peck Centrifugal Concentrator and on four standard makes of slime tables whose names are not given. As a result the round table proved so satisfactory as regards floor space occupied, maintenance, operation, tonnage and efficiency that a 20-deck revolving table 18 ft. diameter has been constructed having decks 1 ft. apart and occupying a space 20 ft. diameter and 30 ft. high. The lower deck acts as a support for the others and is itself supported near the periphery by wheels running on a circular track. Each deck receives the same feed and has its own feed- and wash-water box. The surfaces of the decks are concrete, made of two parts tailings sand and one part cement, reinforced with expanded metal. The surface is finished somewhat rough which has been found to be more efficient than a perfectly smooth finish. The twenty decks are handling 140 tons (dry weight) of slime in 24 hours containing 2 per cent. copper

[1] R. S. Handy, *Min. Sci. Pr.*, CVI, 411 (1913).
[2] H. A. Megraw, *Eng. Min. Jour.*, XCV, 503 (1913).
[3] *Met. Chem. Eng.*, XI, 477 (1913).
[4] *Am. Inst. Min. Eng., Bull.* No. 79, 1173 (July, 1913).
[5] *Am. Inst. Min. Eng., Bull.* No. 80, 1443 (Aug., 1913); No. 83, 2740 (Nov., 1913).

and producing a concentrate containing 7.25 per cent. copper and a tailing containing 1.10 per cent. copper. The slime feed probably consists of about 9 parts water to 1 part solid. The recovery is about 53 per cent. of the copper. It is difficult to get much above 50 per cent. recovery owing to the fact that the slime contains about 20 per cent. of colloidal copper which is not recoverable by wet concentration; and there are middlings grains to be considered as well.

While not within the field of ore dressing still it is proper to call the reader's attention to the success that has been attained by the Anaconda company in recovering copper from tailings and slimes by the Laist roasting and leaching process.[1]

Canvas Tables.—The slime problem at the Federal Lead Company, Missouri, is handled by a canvas plant[2] of the Gates (California) type. The plant contains 48 tables each 11 ft. 8 in. wide, 14 ft. long, sloping 1 9/16 in. per foot, and covered with 18-oz. canvas. Each table is washed once in 20 minutes by a boy who is able to make 24 to 36 washings per hour. The best consistency for the feed is 15 parts water to one part solid by weight. The canvas concentrates are enriched on Wilfley tables and vanners which make concentrates to go to smelter and tailings going back to canvas tables. The plant treats 100 to 120 tons of pulp in 24 hours containing about 81 per cent. water. The final concentrates contain about 35 per cent. lead and the recovery is about 40 per cent. of the lead in the feed which averages 3 per cent. lead.

AMALGAMATION

Successful amalgamation on plates in cyanide solution is reported by the Liberty Bell mill,[3] the secret being that the plates are run "wet" with mercury to prevent the formation of a coating of hard amalgam.

In the Argo mill, Colorado,[4] where the amalgamated plates are short each plate is supplemented by an electrolytic amalgam trap or mercury well. It consists of a lower cone 12 in. diameter and 12 in. deep, holding a copper plate floating on a bath of mercury. The pulp is fed through a 2-in. pipe 3 in. above the copper plate and insulated from the lower cone although rigidly fastened to it. This pipe is enlarged above to 6 in. and forms the anode for the passage of a 6-volt direct current through the pulp to the copper plate cathode.

The recovery of the fine black sand which accumulates on amal-

[1] F. Laist, *Am. Inst. Min. Eng., Bull.* No. 79, 1147 (July, 1913); *Min. Sci. Pr.*, CVI, 644 (1913).
[2] C. T. Rice, *Eng. Min. Jour.*, XCVI, 487 (1913).
[3] H. A. Megraw, *Eng. Min. Jour.*, XCV, 9, (1913); *Jour. Chem., Met. Min. Soc., So. Afr.*, XIII, 625 (1913).
[4] S. L. Goodale, *Eng. Min. Jour.*, XCVI, 385 (1913).

gamated plates has been discussed by J. M. Neill.[1] This sand on the Rand consists mainly of fine iron sulphide, finely divided mercury and perhaps some finely divided metallic iron. It is rich in gold and contains also small amounts of platinum metals.

The regular method of recovery is to brush it off the plates at intervals. By this method a mill recovered one ton of black sand containing 647 oz. fine gold from the treatment of 6188 tons of ore. By a special device the same mill increased the recovery to one ton, containing 1200 to 1500 oz. fine gold from 5000 tons of ore. The device consists of a light flexible floating canvas apron so placed about one-half way down the plate that the pulp flows under it and any fine particles which are being carried along by air bubbles, rise against the under side of the apron where the air bubbles become detached and the particles sink and adhere to the amalgamated plate.

Magnetic and Electrostatic Separation

A new mill has been erected at Mount Summit, New York, for separating magnetite from gneiss.[2] The ore is crushed to 1 1/2 in. in Blake breaker, dried and finally crushed in two Gardner swing hammer crushers to 1/8 in. It then falls in succession past ten horseshoe magnets, each magnet removing a portion of the magnetite concentrate.

The No. 3 mill of the Witherbee Sherman Company for magnetite ore has been described by S. L. Nason.[3] In a general way it follows the practice of No. 1 and No. 2 mills.[4]

The Huff Electrostatic process[5] is in use on zinc-pyrite separation and results published on its work at Midvale, Utah, at Cananea, Mexico, and at Eureka, St. Elmo, and Ouray, Colorado; also on crude silver ore at Austin, Nevada, on molybdenite ore in Australia, and on graphite ore in two mills. Recent tests have shown that this process is very efficient in removing slate from anthracite coal and in removing slate and pyrite from bituminous coal.

Centrifugal Separation

The Peck Centrifugal Slime Concentrators have been on trial at Anaconda.[6] The older machine treats 120 tons of dry slime per day.

[1] *Jour. Chem., Met. Min. Soc. So. Afr.*, XIII, 418, 542 (1913); XIV, 133 (1913); *Met. Chem. Eng.*, XI, 417 (1913); *Min. Sci.*, LXVIII, 50 (1913).
[2] L. O. Kellogg, *Eng. Min. Jour.*, XCVI, 243, 307 (1913).
[3] *Eng. Min. Jour.*, XCVI, 959 (1913).
[4] Richards, *Ore Dressing*, IV, 1820.
[5] F. S. Macgregor, *Am. Electrochem. Soc.*, XXIV, 351 (1913); *Met. Chem. Eng.*, XI, 581 (1913); *Min. Sci.*, LXVIII, 328 (1913); *Min. Eng. World*, XXXIX, 1071 (1913); *Mex. Min. Jour.*, XVII, 492 (1913).
[6] Mineral Industry, XXI, 959.

The speeds of its cones are 473 r.p.m. for the outer cone and 271 for the inner cone. The corresponding figures for the newer machine are 150 tons and 505 and 285 r.p.m.[1]

The Kuchs-Laist separator, which is as yet in experimental stage has been referred to already under the settling of slimes.

The Witherbee concentrator[2] has a capacity of 25 tons per hour separating iron ore below 1/2 in. size at the Madrid mine, Minnesota. The concentrates amount to 84 per cent. of the feed and average 57.5 per cent. iron; the tailings contain about 40 per cent. iron. In principle it resembles an annular hydraulic classifier 3 ft. diameter and 6 ft. high. The ore is fed inside the inner cylinder which revolves and is thrown by centrifugal force out through holes in this cylinder into the annular space between the cylinder and the outer casing which is fixed. There it meets the water rising in the annular space. The action of centrifugal force due to whirling water in the annular space is claimed to offset the action of gravity and thus require a much gentler rising current to lift quartz into the overflow and result in much lower water consumption than in an ordinary classifier.

Dry Concentration

The Sutton, Steele and Steele Process is reported to be in operation in a 50-ton custom and concentrating mill at Denver and in the Yak mill at Leadville.[3]

The Plumb Pneumatic Jig[4] is a recently patented device making use of a revolving cock for producing intermittent pulsations of air through a bed of ore lying on a horizontal screen. By the application of the well-known gate and dam discharge for concentrates it is claimed that this jig is not susceptible to changes in character or rate of feed, a fault which has been found with air jigs in the past. The range of this jig is from 12 to 150 mesh and in actual mill work it has showed excellent separation on material divided into three or four sizes between these limits.

Flotation Processes

The past year has seen a further extension of the flotation processes especially in connection with the treatment of copper ores where the possibilities of higher extractions and reduced costs of plants render them attractive to the mine owners. Smelters still object to the fine zinc and lead concentrates produced by those processes which treat slime. Everywhere investigations are being made to determine the possibilities of the

[1] R. Hayden, *Am. Inst. Min. Eng., Bull.* No. 80, 1463 (Aug., 1913).
[2] B. Crowell, *Lake Super. Min. Inst.*, XVIII, 129, (1913); *Min. Eng. World*, XXXIX, 518 (1913).
[3] *Met. Chem. Eng.*, XI, 50 (1913); *Eng. Min. Jour.*, XCV, 14 (1913).
[4] E. S. Wiard, *Eng. Min. Jour.*, XCVI, 1090 (1913); *Met. Chem. Eng.*, XI, 722 (1913).

application of flotation to ores of widely differing characters. It has been pretty well demonstrated that variations in ores require variations in treatment and that each ore requires careful testing to determine the most suitable conditions and quantity and quality of oil, acid and other reagents; further in actual operation these processes are more delicate than wet concentration and therefore require expert attention. As yet they may be considered to be still in the development stage.

Patent Litigation.—The whole situation is still somewhat complex. The Elmore-Minerals Separation suit now before the Privy Council is as yet undecided. The decision which the Minerals Separation obtained against Hyde in the lower Court in Montana has been reversed by a higher court. What further action will be taken is unknown, but it is believed that ultimately it may be possible to use "froth" flotation in the United States without having to pay royalty on any patented process.

Minerals Separation Process.—This process has shown the greatest growth and it is now in use in mills in various countries.

In Colorado, at Leadville, this process is in use in treating tailings from an old zinc ore dump which are recrushed in a tube mill and at Ouray a mixed sulphide ore which showed heavy losses in slimes in wet concentration is making a good extraction from these slimes by the Minerals Separation Process.[1]

At the Inspiration mill, Arizona, the 50-ton experimental plant gave concentrates containing up to 40 per cent. copper and an extraction of 93 to 94 per cent. on a very low-grade ore, and a 600-ton mill started in December with the possibility of a 6000-ton plant later if results are as expected. It is reported that the process even treated oxidized material with better results than any wet method.[2]

Butte tailings have been the subject of investigation and it is reported that W. A. Clark has secured a license for treatment of zinc ores in Butte.

The Brittania Copper Company in British Columbia having had both wet concentrating mills and magnetic concentrating mill, has now a 400-ton flotation plant which it is proposed to increase to 1000 tons. The ore is ground in Hardinge mills and the extraction is over 94 per cent. on an ore containing 6 per cent. copper in cupriferious pyrite and schist.

At the Braden mill in Chile the first 600-ton Minerals Separation unit was started in November and the second unit was expected to start in December. The final plant will be 3000 tons. The best extraction by wet concentration was 61 per cent. of the copper, but froth flotation has given 80 per cent. even though some of the copper is in the form of oxide

[1] *Met. Chem. Eng.*, XI, 605 (1913).
[2] *Eng. Min. Jour.*, XCVI, 108, 1037 (1913).

and silicate. It is estimated that 90 per cent. of the sulphide copper is saved. Various difficulties have been encountered, many of them trivial; for example one trouble was traced to the lime in the cement used in lining the tube mills. In discussing the Minerals Separation paper of Ashcroft of last year, Broadbridge[1] has given some of the details of the tests at Braden.

The Cuba Copper Company at El Cobre, Cuba, is now obtaining good results from a Minerals Separation plant after having experienced initial difficulties. The plant treats 600 tons daily of a low-grade chalcopyrite ore in quartz gangue. The ore is ground to about 60 mesh in two tube mills and four Hardinge pebble mills and passes through 13 Minerals Separation agitators or separators in series. The tailings are classified in Richards classifiers and treated on Wilfley tables. Each agitator has two propellers or stirrers on one shaft, the upper stirrer having two blades and the lower having four blades. The argument for placing wet concentration after flotation, instead of before as is the usual custom, is that the tables remove coarse concentrates just as well after as before; further the flotation may suddenly fail to give good separation and the tables act as a guard and immediately show that the flotation is not working well and needs attention. One of the difficulties of the process was the recovery of the fine sulphides after they had been floated as froth. Best results have been obtained by using a mixture of various oils and chemicals, some of the oil being added in the grinding mills.

A 600-ton plant has been installed at the Falcon Copper mines in Rhodesia.

In the Minerals Separation Company's annual report comparison is made of wet concentration with flotation.[2] The former treating 1000 tons copper ore requires 174 tables, 41,580 sq. ft. area, 175 h.p. costs $120,000 and yields 70 per cent. recovery; the latter treating 1200 tons requires 3000 sq. ft. area and 80 to 120 h.p. costs $20,000 plus $30,000 for grinding plant and yields 85 per cent. extraction.

Costs of flotation are not given although in another place an estimate of 20 cents per ton is made for flotation alone, not including royalty. This question of royalty has been the stumbling block with some operators who have felt that the Minerals Separation Company demanded too much. It has been reported that the development of the Hyde process was initiated in part by desire to avoid the payment of what were considered to be excessive royalties.

It is an indication of the future possibilities of the Minerals Separation process elsewhere that in the Sulphide Corporation's main mill at Broken

[1] *Inst. Min. Met.*, XXII 3, (1913). *Eng. Min. Jour.*, XCV, 717 (1913).
[2] *Min. Sci. Pr.*, CVI, 246 (1913). *Eng. Min. Jour.*, XCV, 328, 915 (1913).

Hill, the extractions of zinc over the last three successive years have been 85.5, 90 and 94 per cent. respectively.[1]

A very interesting report of froth flotation tests on an antimonial silver ore has been made by D. G. Campbell.[1]

Selective Flotation. Horwood and Lyster Processes.—Up to the present time the Broken Hill concentrate has been largely a mixture of zinc and lead which had to be separated or "deleaded" on tables which made a rather poor separation. The first selective process reported was the Horwood[2] which gave the ore a short sulphatizing roast at 300° to 400° C., which coated the galena with sulphate so that it would not float while the blende remained unchanged. Some mechanical difficulties have been met with, but on the whole the results of the experimental plant are promising.

Several other methods are under investigation all seeming to depend on governing the flotation by control of the character of the pulp and of the chemical character of the solutions.

The Lyster process[3] has been developed at the South Blocks mill at Broken Hill. Slime is thickened and introduced with oil and air to a centrifugal pump where violent agitation occurs. It then passes to a spitzkasten to remove lead froth and the residue is agitated with more oil in a second pump which causes the zinc to float so that it can be recovered in a second spitzkasten. Formerly the lead recovery by jigs and tables was 79 per cent. By the Lyster process 5585 tons of slime containing 10 per cent. zinc, 3.3 oz. silver per ton, and 15 per cent. lead, yielded 1263 tons of lead concentrates containing 7.8 per cent. zinc, 10.1 oz. silver and 54.9 per cent. lead. The extraction was 89.2 per cent. of the lead and 69.2 per cent. of the silver.

The Murex Magnetic Process has six units at Cordova, Spain, on copper ore and two units at Malines Mines, France, where 1000 tons of blende-barite ore are treated per month yielding concentrates with 45 to 50 per cent. zinc and extracting 90 per cent. of the zinc in the ore. At Grund in the Harz Mountains an 80 per cent. extraction is obtained on a silver-lead ore. The concentrates assay 65 per cent. lead and 95 oz. silver per ton. At Whim Well copper mine, West Australia, a 200-ton plant makes an extraction of 75 to 85 per cent. on a 6 per cent. copper ore containing oxides and carbonates. The concentrates assay 20 to 25 per cent. copper. This ore is dry crushed in breaker, rolls and Hardinge mills to 24 mesh and made into a pulp containing 40 per cent. water. The reagents used are 1 1/2 per cent. oil, 3 per cent. magnetic oxide with oleine and silicate of soda.[4]

[1] *Sch. Mines Quart.*, XXXV, 28 (1913).
[2] E. J. Horwood, *Australasian Inst. Min. Eng.* XVI, 228 (1912). J. M. Newman, *Met. Chem. Eng.*, XI, 592 (1913).
[3] J. M. Newman, *Met. Chem. Eng.*, XI, 592 (1913). Loring, *Min. Jour.*, CII, 685 (1913). *Eng. Min. Jour.*, XCVI, 583 (1913).
[4] *Min. Mag.*, IX, 17 (1913). *Eng. Min. Jour.*, XCVI, 128 (1913).

The De Bavay Process is claimed to have yielded the greatest profit of any process on Broken Hill tailings (not slimes). The details of the process are not well known but it makes use of acid, oil and chlorine gas. It treats ore crushed through 30 mesh with 5 to 10 per cent. slimes which is much coarser than can be treated by the Minerals Separation process.[1]

The Macquisten Tube has been described and a flow sheet of the process on tailings at the Morning Mill, Idaho, has been given by O. B. Hofstrand.[2] The tailings are first passed through a dilute sulphuric acid bath of from 0.05 to 0.5 per cent. strength and also a small quantity of soap and oil is added at the feed end of each tube.

The Wood Process has yielded some very satisfactory results in treating Colorado telluride ores. These are reported by Henry E. Wood.[3]

Greased Table.—Prof. H. E. T. Haultain has described a greased table in the form of an endless belt and has given some results obtained with this apparatus in mill work.[4]

Present Conditions at Broken Hill.—The history of milling especially by flotation at Broken Hill and outlines of present plants have been given by J. M. Newman.[5] It is estimated that production is about at its maximum at the present time. The processes used in the various plants are as follows:

(1) Central Mine. Wet concentration. Tailings to Minerals Separation plant; product by wet concentration yields lead and residue which is refloated for zinc.

(2) Junction North. Wet concentration. Tailings to Minerals Separation; product "deleaded" by wet concentration.

(3) Zinc Corporation. Wet concentration. Zincky middlings to Minerals Separation yielding concentrate refloated, and "deleaded" by wet concentration; final middlings to Horwood process. Slimes and original tailings to Lyster plant.

(4) British Mine. Wet concentration and Minerals Separation.

(5) Proprietary Company. Wet concentration. Potter Delprat process on tailings. Slimes not treated.

(6) Amalgamated Zinc Co. De Bavay process on tailings. Product deleaded by wet concentration. Slimes not treated.

(7) South Mine. Wet concentration. Tailings (except slime) to (6).

(8) North Mine. Like (7).

[1] W. Shellshear, *Min. Sci. Pr.*, CVII, 21, 622 (1913).
[2] *Am. Inst. Min. Eng., Bull.* No. 73, Jan., 1913, p. 73. *Min. Sci.*, LXVII, 68 (1913). *Min. Eng. World*, XXXVIII, 1191 (1913). *Met. Chem. Eng.*, XI, 163 (1913). *Eng. Min. Jour.*, XCV, 183 (1913).
[3] *Eng. Min. Jour.*, XCV, 885 (1913). *Min. Mag.*, VIII, 454 (1913).
[4] *Can. Min. Inst.*, XVI, 115 (1913).
[5] *Min. Eng. World*, XXXIX, 331 (1913). *Min. Sci. Pr.*, CVII, 307 (1913). From *Austral. Min. Stand.*

(9) Block 10. Wet concentration. Tailings and slimes sold to flotation plants.

(10) Junction Mine. Wet concentration.

Accessory Apparatus

Elevating Devices.—The tailings wheel on the Rand has been entirely displaced in recent mills by pumps, usually of the Davidson Robeson centrifugal type, but sometimes of the air-lift type.

At Tonopah, Nevada, some of the older mills use tailings wheels for pulp but the newer mills use centrifugal, air lift, plunger or Frenier pumps or sometimes bucket elevators.

To remove sticky ore from elevator buckets the New Reliance mill in the Black Hills uses a plate of iron fitted in the bottom of each bucket and loosely bolted in that position. The result is that when the bucket passes over the head pulley of the elevator the plate falls about an inch and clears the bucket of ore.[1]

A mathematical investigation of the action of gravity and centrifugal force has shown that in the case of every wet bucket elevator working under specified conditions there is a critical speed at which the elevator in question is most efficient, and a chart has been prepared to show graphically the proper relations of belt speed, diameter of pulley and width of bucket.[2]

[1] H. C. Parmelee, *Met. Chem. Eng.*, XI, 435 (1913).
[2] A. O. Gates, *Eng. Min. Jour.*, XCVI, 725 (1913).

LAUNDER DATA OF WASHOE CONCENTRATOR.

Material Handled	Depth, Inches.	Width, Inches.	Grade, Inches per Foot.	Lining.	Ratio, Solids to Water.	Diameter, Largest Particle, mm.	Depth of Stream, Inches.	Per cent. Solids on 60 Mesh.	Remarks.
Undersize 7/8-in. round-hole trommels	15	10	2.0	C.I.	1:3.5	21.0	1.25	82.0	Contains slime.
Undersize 5-mm. round-hole trommels	7	8½	3.0	C.I.	1:5.2	5.0	1.25	75.0	Contains slime.
Undersize 4-mm. round-hole trommels	9½	10½	1.75	C.I.	1:5.0	4.0	1.50	50.0	Contains slime.
Undersize 2 1/2-mm. round-hole trommels	7	8½	2.5	C.I.	1:8.2	2.5	0.50	62.0	Contains slime.
Hutch product of Hare jigs	7	6½	1.0	C.I.	1:22.7	6.0	1.00	95.0	No slime.
Feed to Huntington mill	7	6	1.9	C.I.	1:3.6	2.0	1.25	81.0	No slime.
3/8-in. concentrate	10	9	1.3	C.I.	1:12.8	7.00	1.00	100.0	No slime.
Evans jig concentrate	9½	9½	1.2	C.I.	1:27.8	2.00	1.50	72.5	No slime.
Coarse table feed	7½	7	1.2	None	1:14.2	0.3	0.50	7.0	Contains slime.
Fine table feed	5½	4½	1.2	None	1:13.0	0.2	0.75	0.0	Contains slime.
Table concentrate	11	8½	0.75	None	1:15.6	0.2	0.75	0.0	No slime.
Table middling	4½	5	0.75	None	1:15.6	0.2	0.75	0.0	No slime.
Table tailing	7	7½	0.75	None	1:10.0	0.3	0.50	10.0	A little slime.
Secondary table feed, remodeled section	7	7½	1.20	None	1:7.4	0.9	0.50	44.0	No slime.
Fine primary table feed, remodeled section	7	7½	1.20	None	1:14.0	0.35	0.50	2.0	No slime.
Coarse primary table feed, remodeled section	7	7½	1.20	None	1:4.4	0.9	0.50	46.5	No slime.

LAUNDER DATA, CANANEA CONSOLIDATED MILL.

Material Handled.	Depth, Inches.	Width, Inches.	Grade, Inches per Foot.	Lining (*f*).	Ratio, Solids to Water.	Largest Particle, mm.	Per cent. Solids on 60 Mesh.
Original feed to section C	10	12	3½	C.I. 11¼ in.	1:1	30.0	82.0
Bull jig tails, to coarse rolls	10	9½	3	C.I. 9½ in.	1:1.1	28.0	98.0
Roll jig tails, to fine rolls	10	7½	2½	C.I. 7½ in.	1:3	10.0	98.0
Coarse jig concentrates	10	7½	1¾	C.I. 7½ in.	1:2.9	35.0	95.0(*k*)
Undersize 2-mm. trommel, to classifier	10	5½	1½	C.I. 5½ in.	1:4.4	4.0	52.0(*k*)
First spigot of classifier, to sand jig	8	5½	3½	C.I. 5½ in.	1:1.5	4.0	90.0
Shaking launder for sand jig concentrates (*a*)	6½	12	¾	None-corners	1:19.0	4.0	84.0
Fine jig concentrates from shaking launder	10	7½	1½	C.I. 7½ in.	1:6.0	4.0	80.0
Bryan (Chile) mill discharge to drag belt	8½	11½	1/16	None-corners	1:1.7	2.5	26.0
Drag-belt sands to classifier distributor	10	7½	1¾	C.I. 7½ in.	1:0.9	2.5	46.0
No. 1 spigot of classifier to mud jigs	8	5½	1¾	C.I. 5½ in.	1:17	3.0	60.0
Table feed, tables 27 to 30	7½	5½	¾	None-corners	1:8.4	1.0	0.3
Table concentrates, drag-belt launder (*b*)	9½	9½	¾	1½-in. boards.	1:26	1.0	13.6
Table concentrates, shaking launder (*c*)	4	7½	1/16	None-corners	1:7.4	0.5	35.2
Slimes, section C settling tanks, to section B vanners	6½	9½	1/16	None	1:96	0.17	0.0
Slime feed to vanners, section C	9½	11½(*i*)	¾	None	1:4.7	0.17	0.5
Vanner concentrates, drag-belt launder (*d*)	(*d*)	(*d*)	0	None	1:31	0.2	1.0
Vanner and table concentrates	6½	6	1½	None	1:20	2.0	27.2
Vanner tails, section C	9½	11½	¾	None-corners	1:7	0.4	0.4
Coarse tails, table and jig	9½	22	¾	¾-in. boards and corners (*g*)	1:27	2.0	41.6(*k*)
Coarse sand tails to dam No. 2	12½	11½	¾	¾-in. boards and corners (*g*)	1:21	2.0	19.5(*k*)
Coarse sand tails to dam No. 1	12	11	¾	¾-in. boards and corners (*g*)	1:21	2.0	19.6(*k*)
Slimes to mill No. 4	9½	12½	¾	None-corners	1:4.4	0.1	0.0
Sands and slimes to mill No. 3	10	11½	¾	None-corners	1:5	1.5	2.6
Feed to vanners, mill No. 4	6	7½	¾	None	1:4.4	0.1	0.0
Slime concentrates, mill No. 4, drag-belt launder (*e*)	(*e*)	(*e*)	0	None	.....	0.1	0.2
Slime concentrates, mill No. 4, elevator to bins	7	7½	¾	Glass-corners(*h*)	1:20	0.1	0.4
Slime concentrates, mill No. 3, elevator to bins	10	12	1½	Concrete	1:8.7	0.2	2.8
Slime tails, mill No. 4, to mill No. 3 settling tanks	10	11	1/16	None-corners	1:6.3	0.1	0.0

(*a*) Speed 160 r.p.m., actuated by heavy head motion.
(*b*) Speed 75 ft. per minute; old 4-in. drive belts are used, no scrapers.
(*c*) Speed 180 r.p.m.
(*d*) Speed 75 ft. per minute, 10 × 25 × 16 in.
(*e*) 12 × 24 × 18 in. Speed 75 ft. per minute; old 4-in. drive belts are used, no scrapers.
(*f*) All cast-iron liners have 2-in. effective depth and 24-in. length with corners rounded. "Corners" are strips of wood with cross-section of 45° triangle. nailed in corners of launder.
(*g*) Boards laid with grain across direction of flow.
(*h*) Glass liners 3/4 × 4 × 14 in.
(*i*) Effective width 6 in.
(*k*) Liable to choke.

Launders.—According to Caetani,[1] launders for sand should be broad enough for the sand grains to spread out and roll independently up to the point where the stream of pulp becomes so thin that skin friction has a marked effect in reducing its velocity. Where the flow of pulp is liable to vary a V-shaped launder has the advantage of adjusting itself to the flow of pulp but it should not be used for coarse material running at a minimum grade.

For handling a mixture of very fine sand and slime the launders can be built deep and narrow since the pulp in this case must be considered as a liquid of higher viscosity and specific gravity than water. Pipes work very well on this material and they have the added advantage that they adjust their open area of cross-section in accordance with the flow of pulp; if the pipe is too large it will partly fill with solid; when the flow of pulp increases it will increase the hydrostatic head back of the restricted section and erode the sediment until equilibrium is again established.

Sand may form accretions but they are only banks which are easily eroded while slime has a marked tendency to form slimy or gelatinous deposits which resist the action of fast running water.

A reinforced concrete launder, 36 in. wide and 18 in. deep, details of which are given by C. T. Rice,[2] has been installed for tailings at the Baltic copper mill at Lake Superior.

Launder data of the Washoe Concentrator of the Anaconda Company are shown in the table.[3] The launders are all of wood sometimes lined with cast iron and are rectangular in section. The Anaconda ore contains chalcocite, enargite and pyrite in gangue of quartz and altered granite.

The launder data of the Cananea Consolidated mill are shown in the second table.[4] The ore consists of some native copper with sulphides and oxides mixed with a gangue of diorite, limestone, quartzite and quartz porphyry.

Dewatering Device.—For dewatering sand in some of the South African mills the Caldecott sand filter table is used. It consists of a revolving table 20 ft. in diameter which treats about 350 tons per day reducing the moisture from 30 per cent. in the feed to 12 or 14 per cent. in the discharge.

Principles, Theory and General Ideas

Testing.—A testing plant consisting of crushing machinery, a Wilfley table and a vanner, both full size, with an intermediate classifying tank, has been in use for several years at the Cananea Consolidated mill.[5]

[1] *Min. Sci. Pr.*, CVI, 438 (1913).
[2] *Eng. Min. Jour.*, XCVI, 22 (1913).
[3] *Eng. Min. Jour.*, XCVI, 501 (1913); *Jour. Chem., Met. Min. Soc. So. Afr.*, XIV, 320 (1913).
[4] A. T. Tye and T. Counselman, *Eng. Min. Jour.*, XCV, 375 (1913).
[5] A. T. Tye, *Min. Sci. Pr.*, CVII, 53 (1913).

The plant finds some application in testing new mines or new ore-bodies or regular ores at greater depths, but its main use is to keep track of the regular ores from the various operating mines to determine the yield of copper in concentrating and the resulting profit, or loss, to be credited to each mine, and thus can be figured the grade of ore necessary to pay. Beside separate tests a composite mill test is made every month of all the ores milled during the month, mixed in the same proportion as milled. The results of this test indicate in a concrete form the general tailing, feed, etc., and show what extraction should be shown by the credits from the smelter receipts of concentrates.

Incidentally this scheme saves a great deal of computation and tabulation of weights, assays, and results of all the different shipments of ore milled during the month. That this method gives accurate results, provided samples are correctly taken, is shown by the fact that when compared month by month, it has given results within 1 per cent. of actual smelter returns.

Future Improvements.—It has been pointed out that increased recovery by wet concentration may be obtained along two lines:

(1) Recrushing and retreating middlings; (2) saving fine free mineral going to waste in the tailings.[1] The latter can best be effected by better classification, that is by the use of a systematic rotating or pulsating current to insure absolutely uniform action over the whole area of the sorting column, and also by more classification, that is longer classifiers with more spigots. Wilfley tables which are fed with imperfectly classified feed receive some fine material mixed with coarse and if the tables are adjusted to save the coarse then the fine goes into the tailings; also Wilfley tables which receive too wide a range of feed will lose the finer mineral in the same way. Increasing the number of spigots means closer classification and a narrow range of sizes in the feed to any one table, and if at the same time a good classifier is adopted, then the losses in fine free mineral will be reduced to a minimum. Where several spigot products are made by a classifier they can be best distributed to the proper machines for treating them, that is, the coarse and medium to Wilfley tables and the fine to vanners and round tables.

Foam Process.—A full report has appeared of laboratory tests on the new ore-dressing principle making use of the differences in rates of settling through foam, of different minerals or of different sizes of the same mineral.[2] The object of these laboratory tests, to inspire large scale tests, has been given and the possibility of application in practice discussed. Atten-

[1] R. H. Richards, *Am. Inst. Min. Eng., Bull.* No. 81, 2299 (Sept., 1913) No. 83, 2741; (Nov., 1913); *Min. Jour.*, CIII, 977 (1913); *Mex. Min. Jour.*, XVII, 533 (1913); *Min. Eng. World*, XXXIX, 587 (1913); *Met. Chem. Eng.*, XI, 654](1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 314 (1913).

[2] R. Jaffe, *Metall und Erz*, X, 315, 349 (1913); *Rev. de Met. Extr.*, X, 436 (1913); *Min. Jour.*, CI, 470 (1913).

tion has also been called to the position which the processes, based on this new ore-dressing principle, may take as compared with the older processes.

Mill Construction and Costs.—The subject of mill construction and estimates of cost have been discussed at length by A. M. Merton.[1] Along a somewhat similar line, A. S. Addition has discussed the causes leading to the frequent underestimation of the cost of milling plants.[2]

The subject of mill design and the economics of milling have been gone into in some detail by G. Caetani. The designing of a mill[3] involves the following steps: (1) Decision whether a mill is warranted. (2) Testing of a representative sample of the ore. (3) Small experimental mill if the plant is to be a large one. (4) Selection of site and general arrangement. (5) Drawing of detailed plans. This last step is discussed by the author in detail along the following lines: (1) Separate buildings for coarse crushing, for fine crushing and for settling tanks. (2) Materials of construction, concrete for foundations, steel and wood for structures. (3) Concentration of operations and arrangements for duplicate machines. (4) Systematic arrangement of apparatus. (5) Proper distribution of the ore and products. (6) Allowance for fluctuations and overloads.

That the highest metallurgical recovery in a mill is not necessarily the most economic efficiency has also been shown by several examples from practice.[4] Among the additional factors which effect the economic efficiency are (1) freight and transport charges, (2) smelter schedule, and (3) operating cost. In some cases the value of the additional recovery of metal may not equal the cost of effecting this recovery in the mill. This is true in the big low-grade porphyry mills which are able to make a profit only by loading up the concentrating machines to their highest capacity and thus getting an enormous tonnage at some sacrifice in extraction. Also in some cases high freight charges may warrant increased tailings losses in order to obtain a higher grade concentrate and thus save freight. In other cases smelter schedules may be such that a mill man can get a higher recovery and also a greater profit by mixing a low-grade concentrate with a higher grade.

Examples of Practice

Concentrating Lake Superior Iron Ore.—The American Boston mill[5] at Diorite, near Ishpeming, Michigan, is designed to treat hematite ore and yield 500 tons of concentrates per 24 hours which will contain 60 per cent. iron. It contains some novel features especially Richards pulsator jigs

[1] *Min. Eng. World*, XXXIX, 639, 687, 739, 798, 1149 (1913).
[2] *Min. Sci. Pr.*, CVII, 88, 138, 263, 301 (1913).
[3] G. Caetani, *Min. Mag.*, VIII, 435 (1913); *Met. Chem. Eng.*, XI, 464 (1913).
[4] G. Caetani, *Min. Mag.*, IX, 125 (1913); *Met. Chem. Eng.*, XI, 592 (1913).
[5] F. E. Shepard, *Min. Eng. World*, XXXVIII, 903 (1913); *Met. Chem. Eng.*, XI, 357 (1913); *Min. Sci. Pr.*, CVI, 719 (1913); *Eng. Min. Jour.*, XCV, 311, 1016 (1913).

which are run to yield a large hutch product. The ore passes through gyratory breaker, 5/8-in. trommel and a pair of rolls and is elevated to a double trommel line containing 10-, 7-, 4-, and 2-mm. screens. Over 10 mm. is recrushed in a second set of rolls and goes back to the elevator. The undersizes of 10, 7 and 4 mm. and the dewatered undersize of 2 mm. are treated on nine primary Richards jigs and the tailings of these, except those under 2 mm. in size, are dewatered and retreated on six secondary Richards jigs. All jigs make concentrates from the discharge and hutch. Tailings under 2 mm. are dewatered and sent to 20-mesh Callow belt screen. The oversize is tailing; the undersize, together with slime from the first dewatering of undersize of 2 mm. trommels goes to a 1-spigot Richards pulsator classifier. The spigot goes to a Deister No. 4 table; the overflow is dewatered and goes to a second table. The tables make concentrates and tailings. All concentrates are dewatered, the coarse by boxes and the fine by Ovoca spiral classifier, to 15 per cent. moisture and are elevated to automatic sampler and deposited in a bin with filter bottom. Tailings are also dewatered, elevated and automatically sampled.

Lake Superior Copper Mills.—The Winona mill is one of the newer Lake Superior mills[1] which follows along the general line of treatment of those mills which use the Woodbury system. The ore is hard amygdaloid containing native copper in flaky form and although it averages 1 per cent. copper it is hard to save much over 65 per cent. There are two units, one containing a single steam stamp and one a steeple compound. Each unit has a trommel to receive the stamp discharge and the oversize is treated in a bull jig and then recrushed in rolls. Trommel undersize goes to Woodbury jigs yielding concentrates, middlings to be reground, tailings to waste and fines which are settled and concentrated on Wilfley tables. The regrinding of the middlings is accomplished in Hardinge mills and the product concentrated on Wilfley tables. Some of the specially interesting features of construction and operation are as follows: Beneath each stamp is a circular concrete pier 47.5 ft. deep and 15 ft. diameter with a mushroom base and a large cap 22 ft. diameter. This supports the 80-ton iron mortar block and the 115-ton steam stamp. Concrete is used for foundations, floors and settling tanks, steel for the structure and for the bins, double cement plaster walls for the sides and wood for the roof with skylights of wire glass. Wooden dams near eaves keep back water from melting snow in winter and deliver it to drain pipes passing down through the mill. This prevents freezing at the eaves and backing up with consequent leakage through the roof. Jig tailings are unwatered by a large 12-ft. raff wheel with radial blades and thence removed from the mill

[1] R. R. Seeber, *Lake Super. Min. Inst.*, XVIII, 43 (1913); *Met. Chem. Eng.*, XI, 549 (1913); *Min. Sci. Pr.*, CVII, 339 (1913); *Jour. Chem., Met. Min. Soc. So. Afr.*, XIV, 276 (1913).

by 20-in. troughing belt conveyor inclined 1 3/4 in. per foot and elevating to a point 123 ft. above the ground. Fine tailings flow away in a steel launder 1200 ft. long with semi-circular bottom, sloping 1/4 in. per foot. The Hardinge pebble mills are doing very good work at a cost of 29.63 cents per ton reground. The size preferred is 8 ft. by 36 in.

The new Calumet and Hecla regrinding plant which is to recover native copper from the present and accumulated mill tailings, is to have a capacity of 3000 tons per 24 hours. It is to contain 64 Hardinge conical pebble mills for grinding, and classifiers and Wilfley tables are to be used for concentration. It is expected that the tailings from this plant will contain 7 to 8 lb. of copper per ton (0.35 to 0.40 per cent.) but the company has not felt satisfied to rest content and it is reported that by subsequent leaching they expect to reduce the final tailing to about 3 lb. of copper per ton. This leaching process is understood to make use of ammonium carbonate as a solvent.

The example of Calumet and Hecla mill has apparently led to the new regrinding plant at the Baltic mill.[1] The middle heads from jigs (60 to 70 tons per 24 hourr are sent to (1) and the middle heads and tailings from finishing tables (40 to 45 tons per 24 hours) are sent to (3).

1. One 8-ft. by 30-in. Hardinge pebble mill. To (2).
2. Four Wilfley tables. Concentrates to smelter; Middlings to (5); tailings to waste.
3. One 6-ft. by 22-in. Hardinge pebble mill. To (4).
4. Four Wilfley tables. Products like (2).
5. One Wilfley table. Concentrates to smelter; tailings to waste.

There are four of these units, one for each steam stamp. The economy of this plant is due in part to the use of a low pressure steam turbine which is driven by the exhaust steam from the steam stamps.

Concentrating Butte Copper Ores.—In a very complete and valuable paper A. E. Wiggin[2] has given the history of the development of the Great Falls System of Concentration, which is in use in one of the units of the Washoe mill at Anaconda. The ore, which consists of chalcocite and other sulphides in quartz and granite, amounting to 500 tons in 24 hours, is fed to (1).

1. Ore bin, holding 1000 tons. By two gates to (2).
2. Two shaking screens with 2-in. round holes. Oversize to (3); undersize to (6).
3. Blake breaker, 12 by 24 in., crushing to 2.5 in. To (4).
4. Two trommels, 3 by 6 ft., with 2-in. round hole cast manganese steel screens. Oversize to (5); undersize to (6).
5. Two Blake breakers, 5 by 15 in., crushing to 2 in. To (6).
6. Elevator. To (7).

[1] A. H. Sawyer, *Eng. Min. Jour.*, XCV, 521 (1913).
[2] *Am. Inst. Min. Eng., Bull.* No. 80, 1801 (Aug., 1913); *Mines and Methods*, IV, 159 (1913).

7. Four trommels, 3 by 6 ft., with 1-in. round hole sheet steel screens. Oversize to (9); undersize to (8).

8. Four trommels, 3 by 6 ft., with 10-mm. round hole sheet steel screens. Oversize to (11); undersize to (13).

9. Two 2-compartment coarse Harz jigs. Discharge, unwatered on shaking screen, goes by inclined conveyor to coarse concentrates bins; concentrates water to undersize of (2); hutch to (14); tailings unwatered on inclined screens to (10); tailings water to (14).

10. One set coarse rolls, 24 by 54 in., crushing to 1 in. To (6).

11. Four 2-compartment fine Harz jigs. Products similar to (9) except unwatered tailings to (12).

12. One set fine rolls, 24 by 54 in., crushing to 10 mm. To (6).

13. Eight trommels, 3 by 6 ft., with 4-mm. round hole sheet steel screens. Oversize to (14); undersize to (18).

14. Two coarse 19-ft. Hancock jigs (trays 15 ft. long); first three hutches (called 3/8-in. concentrate) to dewatering tanks in tank house; fourth hutch is middlings, dewatered and returned to jig; fifth and sixth hutches, dewatered, to (15); water used on (20).

15. One set of intermediate rolls, 16 by 42 in. crushing to 4 mm. To (16).

16. Elevator. To (17).

17. Six trommels, 3 by 6 ft., with 4-mm. round holes. Oversize to (15); undersize to (18).

18. Six No. 1 Anaconda classifiers each with one spigot. Spigot to (19); overflow (0.08 mm. to 0 quartz) to (33).

19. Six No. 2 Anaconda classifiers, each with one spigot. Spigot (4 to 0.75 mm. quartz) to (20); overflow (0.75 to 0.08 mm. quartz) is dewatered and goes to (30); water used as wash water on Wilfley and round tables.

20. Three fine 19-ft. Hancock jigs with 15-ft. trays. First three hutches are concentrates; fourth hutch is middlings, dewatered and returned to jig; fifth and sixth hutches, dewatered, to (21); water used as wash water on Wilfley tables.

21. Eight trommels, 3 by 8 ft., with 1.25 by 12-mm. slotted steel screens. Oversize to (22); undersize to (23).

22. Two sets of rolls, 16 by 42 in. By elevator to (21).

23. Eight No. 3 Anaconda classifiers each with one spigot. Spigot to (24); overflow (0.08 mm. to 0) to (33).

24. Six No. 4 Anaconda classifiers, each with one spigot. Spigot (1.25 to 0.75 mm.) to (25); overflow (0.75 to 0.08 mm.) is dewatered and goes to (29); water used as wash water on Wilfley tables and round tables.

25. Nine coarse middling Wilfley tables. Concentrates; middlings to (19); tailings to (26).

26. Two No. 5 Anaconda classifiers, each with one spigot. Spigot to (28); overflow to (27).

27. Dewatering tanks. Water used in (24); residue to tailings launder.

28. Four 6-ft. Huntington mills with 0.75 by 12-mm. slotted steel screens. To (23).

29. Twenty-three secondary Wilfley tables. Concentrates; middlings to (19); tailings to waste.

30. Three No. 6 Anaconda classifiers, each with one spigot. Spigot (0.75 to 0.35 mm.) to (31); overflow (0.35 to 0.08 mm.) is dewatered and goes to (32); water used as wash water on Wilfley and round tables.

31. Twelve coarse primary Wilfley tables. Products like (29).

32. Nineteen fine primary Wilfley tables. Products like (29).

33. Fourteen Dorr thickening tanks, each 28 by 3 ft. These receive only about 50 tons of slime pulp with 2 per cent. solids per 24 hours or 20 per cent. of the total slime, the remainder going to settling ponds. Thickened pulp to (34); overflow clean water.

34. Thirty-five round table decks, 18 ft. diameter. Concentrates; middlings returned to tables; tailings to waste.

A test at Great Falls of a unit like that just described and treating Butte ore gave results shown in the table.

Product.	Solids per 24 Hours.	Assay.		Copper per 24 Hours.	Per cent. of Original.	
		Copper.	Silica Plus Alumina.		Solids.	Copper.
	Pounds.	Per cent.	Per cent.	Pounds.		
Crude ore	986,075	3.51	73.3	34,651	100.0	100.0
Coarse concentrate	67,000	13.83	24.5	9,266	6.8	26.7
Fine concentrate	166,595	10.00	13.7	16,652	16.9	48.1
Slime concentrate	42,610	9.49	53.8	4,044	4.3	11.7
Total concentrate	276,205	10.85	22.5	29,962	28.0	86.5
Mill tailing	469,120	0.40	96.3	1,900	47.6	8.5
Slime tailing	211,745	1.01	87.0	2,149	21.5	6.2
Total tailing	680,865	0.59	93.4	4,049	69.1	11.7
Overflow loss	29,005	2.21	82.5	640	2.9	1.8
Total products	986,075	3.51	73.3	34,651	100.0	100.0

This flow sheet may be considered to be the result of the policy of this company to carry on complete and systematic testing in all departments. It was one of the first to organize a large testing staff and its example is being followed by other large companies.

The marked features of the flow sheet are: (1) the stage treatment especially in recrushing of middlings; (2) the use of Hancock jigs which have been proved to have an economic limit at 0.17 mm. chalcocite and do work superior to Evans jigs; (3) the use of desliming classifier preceding sand classifier in every case, thus avoiding losses of fine free mineral which formerly occurred in Wilfley tailings; (4) the use of Wilfley tables treating chalcocite down to 0.18 mm. or 200 mesh which has been proved to be the fine limit for these tables.

Wet Concentration of Oxide Copper Ores is usually considered to be a difficult task. The Arizona Copper Company is able to recover by jigs

and tables about 30 per cent. of the copper in a 2.5 to 3 per cent. ore. The tailings are further reduced by sulphuric acid leaching to 0.4 to 0.6 per cent. copper. The advantage of the concentration is that it yields material in coarse condition for the blast-furnace and at the same time reduces the duty of the acid in the leaching process.[1]

Milling Lead Ore in Southeast Missouri.—C. T. Rice[2] has contributed a very comprehensive article on three lead mills of this district. The system at the Doe Run No. 3 mill at Rivermines makes use of Hancock and Woodbury jigs; that at the Federal mill uses Symons gyratory and disk crushers, Esperanza-Federal drag classifiers, Hancock jigs, roasting and magnetic plant for Wilfley table middlings and a canvas plant for slimes; the experimental plant of the St. Louis Smelting and Refining Company has the Overstrom system of classifiers and tables, eliminating the slimes at the beginning of the classification. A perusal of the original article is recommended to the reader who desires full details of the milling practice of this district.

The new No. 3 mill at Flat River has also been described by S. R. Stone.[3]

Idaho Lead Milling.—The new No. 2 unit of the West Bunker Hill & Sullivan mill[4] uses jigs, tables and vanners with graded reduction of middlings along the line of the No. 1 unit.[5] Chile and Hardinge mills have been used in place of Huntington mills, and other new machines are the Esperanza classifier and Blake Dennison conveyor-weigher. Other novel details are the use of manganese steel roll shells trued up with carborundum bricks; revolving trommel roll feeders; the drilling of holes in the bottom of fine-elevator buckets to destroy suction; the use of pure rubber washers between the elevator buckets and the belt to pass the fine sand and avoid wear of belt; air lift for returning overflow water from ore bins, etc., for table wash water; Keystone grease cups with copper pins on all bearings; the use of double-edged or overflow boxes in the thickening tanks. Full details of each machine are given in the original article.

Lead-Zinc Mill in Tunis.—The new Djebel Ressas mill[6] treats mixed ores containing sulphide and carbonate of lead and sulphide, carbonate and silicate of zinc. Extensive hand picking and cobbing are practiced to obtain various grades of marketable products, milling products, calcining products and waste. There are four separate divisions for wet concentration of the milling grades. These are up-to-date plants containing

[1] *Min. Mag.*, VIII, 405 (1913).
[2] *Eng. Min. Jour.*, XCV, 1229, 1283; XCVI, 7, 57 (1913).
[3] *Min. Eng. World*, XXXVIII, 97 (1913).
[4] R. S. Handy, *Am. Inst. Min. Eng., Bull.* No. 73, 65, (Jan., 1913); *Met. Chem. Eng.*, XI, 163 (1913); *Min. Eng. World*, XXXVIII, 292 (1913).
[5] MINERAL INDUSTRY, XIX, 773.
[6] M. Lyon, Mercier-Pageyral, and F. Laborde, *Bull. Soc. l'Ind. Min.*, [V], IV, 405 (1913).

breaker, rolls, trommels, classifiers, Callow screens, jigs, Wilfley tables, James tables, Linkenbach tables and Isbell vanners.

Australia and Tasmania.—The lead concentrating mill of the Broken Hill Junction North Mine is one of the newer mills at Broken Hill.[1] It uses breakers, hand-picking, rolls, trommels, jigs, tube mills, grinding pans, Wilfley tables and vanners. The ore contains sulphides of lead, zinc and iron in a gangue of rhodonite and quartz.

The Magnet Silver lead mill in Tasmania[2] uses breaker, rolls, trommels, jigs, classifiers, rolls and grinding pans for recrushing, Callow screens, Card tables and Luhrig vanners.

Cornish Tin Dressing has been the subject of four valuable papers and considerable discussion.[3] The losses of tin are chiefly in the slimes in the form of very fine or even colloidal cassiterite and in some cases in the form of silicate of tin or of a low-grade mineral mixture of tin oxide and iron oxide. Chemical assay shows that these losses are greater than is indicated by the commonly used vanning tests and probably amount to 30 or 40 or even 50 per cent. of the tin in the ore. Losses have been somewhat reduced by the use of coarser stamp screens, 10 or 15 mesh instead of 20 or 30 mesh, and by the installation of regrinders for coarse middlings. Better classification, it is believed, will still further reduce the losses.

Treatment of Zinc Retort Residues has always been a difficult problem. Lindt[4] reports good results by wet concentration if the material is given a preliminary separation by electromagnets.

Treatment of Coal

Although there have been no marked developments in coal washing on the technical side, there has been a steady growth in the practical application of the process. The mine which makes dirty coal is forced to clean it in order to compete with mines which make clean coal either direct or by washing. The practice of purchasing coal on a heat unit basis also has been a factor in obliging a mine to wash dirty coal in order to sell it.

The foreign tendency to use elaborate plants and to give the coal a very careful treatment is illustrated by the Horloz coal washery[5] and by the washery at Flenu.[6] The former sizes with screens 6, 10, 20, 30, 50 and

[1] S. C. Bullock, *Inst. Min. Met.*, XXII, 493 (1913); *Met. Chem. Eng.*, XI, 163 (1913); *Metall und Erz*, X, 426 (1913); *Min. Eng. World*, XXXVIII, 252 (1913).
[2] P. G. Tait, *Min. Sci. Pr.*, CVII, 102 (1913).
[3] W. F. Wilkinson, Dressing Tin Ores in Cornwall, *Inst. Min. Met.*, XXII, 215, 246 (1913); *Min. Mag.*, VIII, 44, 64 (1913). W. Thomas, Losses in Tin Dressing, *Min. Mag.*, VIII, 376 (1913); *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 94 (1913). H. W. Hutchin, Milling Cornish Tin Ores, *Min. Mag.*, VIII, 284 (1913). J. Paull, Coarse Crushing of Tin Ores at South Crofty, *Min. Mag.*, VII, 454 (1913).
[4] *Metall und Erz*, X, 347 (1913); *Rev. de Met. Extr.*, X, 456 (1913); *Eng. Min. Jour.*, XCVI, 119 (1913); *Min. Jour.*, CI, 578 (1913).
[5] Fourmarier, *Ann. des Mines de Belg.*, XVIII, 1149 (1913).
[6] Niederau, *Ann. des Mines de Belg.*, XVIII, 1163 (1913).

80 mm., each size being jigged separately; the latter makes sizes, 2, 4, 8, 15, 25, 50 and 70 mm. and also treats each size separately.

The sludge question is receiving attention in coal washing. Not only can the sludge (below about 0.5 mm.) not be separated into slate and coal by washing but its presence hinders the washing of coarser coal with which it is mixed, and it makes the water dirty so that it cannot be used again. A further disadvantage is that fine sludge holds a high percentage of moisture which makes it bad for coking. These troubles may be avoided by the use of shaking or vibrating screens to remove the fine coal at the outset. If the coal does not contain over 4.5 per cent. moisture these screens work well down to 1 mm. size, but if the moisture content is higher then the limit is 1.2 or 1.4 mm. Usually the fine material thus screened out has a high percentage of ash and although in some cases it may be wise to mix it with the washed coal, it is generally better to burn it under the boilers or to send it to coke ovens where its greatest value lies in the form of by-products.[1]

The advantage of removal of fines and slimes as the first step in coal washing has been shown by some tests at Clausthal. If this is done it is possible to obtain good separation by jigging as fine as 0.3 or even 0.2 mm., but where it is not done the limit is about 0.5 mm.[2]

Apparatus.—A Morrow balanced steel shaking screen of novel design has been installed at Tazewell, Virginia, for the Jewell Ridge Coal Corporation.[3]

Balanced shaking screens operated by eccentrics and rods have given no trouble in a reinforced concrete building during an operation of one and one-half years at Stearns, Kentucky. Their success is due to careful calculation of the balance and to the use of shorter suspending hangers. Incidentally this last feature increases the efficiency of the screens.[4]

Arrangement of either fixed or inclined screens in short sections with a little drop from one section to the next is reported to give more efficient screening than one long screen.[5]

The Marcus combined screening and picking table is a foreign device which has been applied successfully to bituminous coal in West Virginia and Illinois.[6] It consists of a horizontal shaking conveyor having a mechanism for progressing the coal forward. A fine screen at the head removes slack and the coarse residue continues on over a dead plate where slate is picked out by hand. If desired, nut and egg screens may follow for screening out these sizes.

A launder classifier with cross slots has supplanted jigs for washing

[1] J. D. Paton, *Coal Age*, IV, 573 (1913).
[2] F. Jungst, *Glückauf*, XLIX, 1321 (1913).
[3] W. F. Schadel, *Coal Age*, III, 682 (1913).
[4] O. G. Peterson, *Coal Age*, III, 958 (1913).
[5] *Coal Age*, III, 681 (1913).
[6] F. E. Mueller, *Coal Age*, III, 668 (1913).

coal at the St. Nicholas pit neat Liége, Belgium.[1] Sized coal up to 60 mm. in size is reported to be treated more economically and to give better products by this classifier than by jigs. Probably a pulsating classifier would give even better results.

The Nassco table represents an adaption of the Wilfley table to the work of coal washing. The special feature is that the riffles extend the full length of the table.[2]

The well-known Emery gravity slate picker for anthracite used the principle of dropping the slate through gaps as it passed down an incline. Recently the Emery flat slate picker has also appeared. This makes use of cross slots between loose overlapping plates much like fish scales which are placed in the bottom of a flat shaking chute. As the coal and slate are progressed along this chute by a shaking action, the flat pieces of slate work their way down between the plates while the coal passes on to the end of the chute.[3]

The Langerfeld automatic slate picker for anthracite coal has been improved by the use of a corrugated feed plate which prevents fine material from affecting the velocities of lumps of coal or slate as they roll or slide down the incline preparatory to jumping the gap at the bottom.[4]

For handling waste slush, all below 7/16 in. one anthracite washery, which formerly used bucket elevators, now uses a vertical, triplex, single acting, cement lined, motor-driven plunger pump and reports that the cost is cut in half.[5]

Bituminous Practice.—Bradford washers are used at the plant of the By-product Coke Corporation at Solvay, Illinois. Each machine treats 125 to 150 tons per hour. The washed coal passes over belt magnets to remove scrap iron and is then crushed in No. 6 Williams crusher before going to coke ovens.[6]

The Central Washer of the Alabama Fuel and Iron Company is located at Colgate Station, Ala.[7] At the mines coal is screened on two balanced shaking screens with 4-in. and 2-in. perforations. Oversize of 4 in. is hand picked; the nut coal, from 4 in. to 2 in., and the slack, below 2 in., are loaded separately and hauled by railroad to the central washer and delivered to (1).

1. Two bins for nut and 6 for slack, each holding 150 tons. To (2).

2. Twenty jigs, 8 for nut and 12 for slack. Total capacity 3500 tons in 10 hours. Jigs of American Concentrator fixed sieve type with special cast-iron circular plunger. Coal to (3); slate to (5).

[1] L. D. Ford, *Inst. Min. Eng.*, XLVI, 423 (1913).
[2] *Min. Sci.*, LXVIII, 343 (1913); *Coal Age*, IV, 732 (1913).
[3] F. H. Kneeland, *Coal Age*, III, 680 (1913).
[4] A. Langerfeld, *Coal Age*, III, 185 (1913); *Coll. Eng.* XXXIII, 656 (1913).
[5] *Coal Age*, III, 518 (1913).
[6] M. J. Williams, *Coal Age*, III, 889 (1913).
[7] E. H. Coxe, *Coal Age*, III, 247, 301 (1913).

3. Two settling tanks with two perforated bucket elevators. To (4).

4. Two 24-in. smooth belt inclined conveyors to washed coal bins.

5. Ten tanks, one for each pair of jigs, with ten bucket elevators delivering to cross belt and thence to main 22-in. belt to waste dump.

The main washer building is of reinforced concrete; the shed over the unloading platform is of corrugated iron on a steel frame; the sheets over the belt galleries and the washed coal bins are of wood.

The washer reduces Margaret raw coal with 25 per cent. ash, down to 7 per cent. ash; Acmar coal is reduced from 18 per cent. down to 10.5 per cent.

An up to date bulletin on coal washing with special reference to the treatment of Illinois coals has been written by F. C. Lincoln.[1]

Bibliography of Ore Dressing and Coal Washing in 1913

For want of space the following contributions to the literature on the subject are referred to by title only. This list contains only articles which are not referred to in the text.

Crushing and Grinding

Anon.—Acton Stone Crushing Plant at Los Angeles. *Eng. News*, LXV, 688 (1913).

Anon.—Adjustable Quick Discharge for Tube Mills. *Min. Eng. World*, XXXIX, 717 (1913).

Anon.—Griffin Mill. *Coll. Guard.*, CVI, 1272 (1913).

Anon.—Hardinge Conical Mills on Coarse and Fine Crushing. *Eng. Min. Jour.* XCV, 663 (1913).

Anon.—Hardinge Mill. *Engineering*, XCV, 802 (1913).

Anon.—Improved Mortar Base for Stamp Mills. *Min. Sci. Pr.*, CVI, 803 (1913).

Anon.—Jeffrey Swing Hammer Pulverizer. *Eng. Min. Journ.*, XCVI, 30 (1913).

Anon.—Komata Liners for Tube Mills. *Min. Eng. World*, XXXVIII, 1050 (1913). *Can. Min. Journ.*, XXXIV, 134 (1913).

Anon.—Large Gyratory Breaker. *Stahl und Eisen*, XXXVII, 1533 (1913).

Anon.—Large Jaw Breakers. *Eng. Min. Jour.*, XCV, 232 (1913).

Anon.—Lovett Grinder. *Min. Sci. Pr.*, CVII, 372 (1913).

Anon.—Mixing and Grinding Machinery. *Met. Chem. Eng.*, XI, 111 (1913).

Anon.—Multiple Grinder or Disintegrator. *Coll. Guard.* CVI, 526 (1913).

Anon.—New Grinding Pan. *Eng. Min. Jour.*, XCVI, 792 (1913).

Anon.—Pebble Feeder for Tube Mill. *Eng. Min. Jour.*, XCV, 806 (1913).

Anon.—Proper Adjustments for Tube Mills. *Min. Sci. Pr.*, CVII, 580 (1913).

Anon.—Rock Crushing Efficiency. *Met. Chem. Eng.*, XI, 49 (1913).

Anon.—Stamp Mills of the Past. *Min. Sci. Pr.*, CVII, 462 (1913).

[1] *Univ. of Ill. Bull.*, XI, No. 9 (1913).

ANON.—The Largest Tube Mill Plant. *Min. Sci. Pr.*, CVI, 699 (1913).

ANON.—Tube Mill Circuit at Alaska Treadwell Mill. *Eng. Min. Jour.*, XCVI, 502 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 320 (1913).

BANKS, R. T. and SINCLAIR, H. L.—Nissen Stamps in Colorado. *Min. Sci.*, LXVIII, 56 (1913).

BROWN, F. C.—Komata Tube Mill Liner. *Jour. Chem. Met. Min. Soc. So. Afr.* XIII, 507 (1913). From *Eng. Min. Jour.*, XCIV, 1135 (1912).

CARTER, E. E.—Slow Speed Chile Mill. *Min. Sci. Pr.*, CVI, 863 (1913).

DAVIS, R. O. E.—Results of Tests Showing Increased Efficiency of Balls over Cylinders in Grinding Soft Sticky Rock in Pebble Mills. *Eighth Internat. Cong. Appl. Chem.*, XV, 73 (1912).

DEL MAR, A.—Mechanical Efficiency in Crushing. *Eng. Min. Jour.*, XCV, 242 (1913).

HOOD, O. P.—Balancing Rock Breakers. *Min. Sci.*, LXVII, 53 (1913).

KILIANI, R. B. T.—Fine Grinding of Ores in Hardinge Mills. *Eng. Min. Jour.*, XCVI, 1085 (1913).

RANDALL, J.—Grinding Pans. *Min. Sci. Pr.*, CVII, 233 (1913).

SCHINDLER, A.—Capacities of Large Ore Breakers. *Stahl und Eisen*, XXXIII, 435 (1913).

SCHMITT, C. O.—Stamp Battery Water Supply. *Eng. Min. Jour.*, XCV, 473 (1913).

SOEHNLEIN, M. G. F.—Grinding Pan Practice. *Min. Sci. Pr.*, CVII, 900, (1913).

TAFT, J. R.—Voids in Crushed Stone. *Eng. News*, LXV, 26 (1913).

VAIL, R. H.—No. 2 Crushing Plant of Natomas Consolidated, California. *Eng. Min. Jour.*, XCVI, 481 (1913).

VON BERNEWITZ, M. W.—Dry *vs.* Wet Crushing at Kalgoorlie. *Min. Sci. Pr.*, CVI, 409 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 30 (1913).

Screening, Classifying and Settling

ANON.—Classifiers. *Metall und Erz*, X, 404 (1913).

ANON.—Conical Trommels. *Eng. Min. Jour.*, XCVI, 645 (1913).

ANON.—Major's Mechanical Classifier. *Min. Mag.*, VIII, 63, (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 440 (1913). From *Eng. Min. Jour.*, XCIV, 977 (1912).

ANON.—Michel Hydraulic Classifier. *Eng. Min. Jour.*, XCVI, 693 (1913). *Genie Civil*, LXIII, 134 (1913).

ANON.—Shields-Thielman Sectional Jig Classifier at Quincy Mill, Michigan. *Can. Min. Jour.*, XXXIV, 782 (1913). *Min. Sci. Pr.*, CVI, 862 (1913).

ALLEN, A.W.—Effect of Colloids in Settling Slimes. *Min. Sci. Pr.*, CVII, 109 (1913).

BLEININGER, A. V.—Use of Electrolysis in Washing Clay. *Am. Ceram. Soc.*, XV, 338 (1913).

BRADBURY, R. H.—Colloids and Crystals. *Jour. Frank. Inst.*, CLXXVI, 319 (1913).

FLEISSNER, H.—Investigation on Clarifying Water at Birkenberg. *Oester. Zeit. f. Berg. Hutten.*, LXI, 531, 550 (1913).

IRVIN, D. F.—Automatic Indicator for Drag Classifiers. *Eng. Min. Jour.*, XCV, 663 (1913).

KERR, C. H.—Standard Testing Sieves. *Am. Ceram. Soc.*, XV, 375 (1913).

MISHLER, R. T.—Settling Slime at El Tigre Mill. *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 340 (1913). From *Eng. Min. Jour.*, XCIV, 643 (1912).

RICE, C. T.—Joplin Intermittent Settling Tank. *Eng. Min. Jour.*, XCV, 1198 (1913).

RICHARDS, R. H.—Standard Screens for Screen Analysis. *Jour. Chem., Met. Min. Soc. So. Afr.*, XIV, 12 (1913). *Mex. Min. Jour.*, XVI, 242 (1913). *Met. Chem. Eng.*, XI, 168 (1913). *Eng. Min. Jour.*, XCV, 390 (1913). *Min. Eng. World*, XXXVIII, 341 (1913). *Min. Sci. Pr.*, CVI, 312 (1913).

ROLLANDET, G. J.—The Stanley Classifier. *Min. Sci.*, LXVII, 133 (1913).

SOEHNLEIN, M. G. F.—Regulating Moisture In Sand Discharged by Dorr Classifier. *Eng. Min. Jour.*, XCVI, 215 (1913).

STADLER, H.—Uniformity in Grading Analyses. *Mex. Min. Jour.*, XVII, 447, (1913). From *So. Afr. Min. Jour.*

Hand Picking. Concentrating Machines

ANON.—Adjustable Draw-off for Jig Middlings. *Eng. Min. Jour.*, XCVI, 119 (1913).

ANON.—Darrow-Hambric Canvas Tables. *Mex. Min. Jour.*, XVII, 597 (1913).

ANON.—Intermittent Sorting Belts. *Eng. Min. Jour.*, XCV, 1150 (1913).

ANON.—New Double Acting Jigs. *Glückauf*, XLIX, 1477 (1913).

ANON.—Practical Details for Good Ore Sorting. *Min. Sci. Pr.*, CVI, 349 (1913).

ANON.—Sorting out Waste in Joplin District of Missouri. *Min. Sci. Pr.*, CVI, 220 (1913).

ANON.—Wilfley Tilting Concentrator. *Eng. Min. Jour.*, XCVI, 24 (1913).

BOUERY, P.—Riffles for Hydraulicking. *Eng. Min. Jour.*, XCV, 1055 (1913).

MCDONALD, P. B.—Hand Picking Iron Ore. *Eng. Min. Jour.*, XCVI, 848 (1913).

SCHMITT, C. O.—Sorting Belts and Tables on the Rand. *Eng. Min. Jour.*, XCV, 21, 279 (1913).

SPICER, H. N.—Handling Slime. *Met. Chem. Eng.*, XI, 181, 239, 315, 408, 451, 481 (1913).

STOVALL, D. H.—Burlap Tables for Saving Platinum. *Min. Eng. World*, XXXVIII, 1132 (1913).

WRIGHT, E. T.—Woodbury Jig. *Mines and Minerals*, XXXIII, 397 (1913).

Amalgamation

ANON.—Effect of Heat on Amalgamating and Concentrating in Cyanide Solution. *Met. Chem. Eng.*, XI, 98 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 11 (1913).

MERTON, A. M.—Mexican Method of Retorting Amalgam. *Eng. Min. Jour.*, XCVI, 263 (1913).

SCHMITT, C. O.—Improved Rand Amalgamating Tables. *Eng. Min. Jour.*, XCV, 804 (1913).

WHITE, H. A.—Area of Amalgamated Plates. *Eng. Min Jour.*, XCV, 375 (1913).

Magnetic and Electrostatic Separation

ANON.—Concentrating Magnetic Iron Ore at Trenton, Ontario. *Can. Min. Jour.*, XXXIV, 397 (1913).

ANON.—Electromagnetic and Electrostatic Ore Separation. *Metall und Erz*, X, 726, 752, 791, 914 (1913).

ANON.—Magnetic Separation of Pyrite and Blende, Campbell Process. *Eng. Min. Jour.*, XCVI, 24 (1913). *Met. Chem. Eng.*, XI, 297 (1913).

ANON.—Removing Iron from Pulp. *Eng. Min. Jour.*, XCVI, 452 (1913).

ANON.—Ullrich Magnetic Separator. *Eng. Min. Jour.*, XCVI, 927 (1913). *Min. Jour.*, CIII, 1022 (1913).

ANDRE, P.—Electromagnetic Separation of Blende and Pyrite. *Bull. Soc. l'Ind. Min.* [V], IV, 383 (1913).

DE TOLENTINO, C.—Ullrich Magnetic Separator. *Compt. rend. mens. Soc. l'Ind. min.*, Dec., 1913, p. 685.

HARNICKELL, W.—Magnetic Concentration of Spathic Iron Ore. *Rev. de Met., Extr.*, X, 545 (1913). From *Stahl und Eisen*, XXXII, 1949 (1912).

HERMANNS.—Magnetic Separation of Iron Ore. *Zeit. des Verein. Deutsch. Inge.*, LVII, 476 (1913).

KRANAFELDT.—Electromagnetic Ore Separation by Ullrich Separator. *Can. Min. Jour.*, XXXIV, 703 (1913).

MUELLER, R.—Magnetic Separator of Drum Type. *Dingl. Polytech. Jour.* CCCXXVIII, 330 (1913).

PAYNE, C. Q.—Magnetic Concentration of Iron Ores. *Am. Inst. Min. Eng., Bull. No.* 75, 529 (March, 1913). *Met. Chem. Eng.*, XI, 289 (1913).

REUTER, F.—Magnetic Separation of Iron Ore in Upper Silesia. *Glückauf*, XLIX, 1925 (1913).

SCHMITT, C. O.—Magnetic Separator in Tube Mill Circuit. *Eng. Min. Jour.*, XCV, 758 (1913).

SCHMITT, C. O.—Magnetized Pulleys for Conveyor Belts. *Eng. Min. Jour.*, XCV, 424 (1913).

WILFLEY, C. R.—Electrostatic Separation of Barstow Concentrate. *Eng. Min. Jour.*, XCVI, 249 (1913).

Centrifugal and Dry Separation

ANON.—Separator for Dry Material. *Eng. Min. Jour.*, XCVI, 166 (1913).

GODFREY, M., and VIVIAN, F.—Centrifugal Machine for Classification and Concentration. *Rev. de Met., Mem.*, X, 879 (1913).

Flotation Processes

ANON.—Details of Court Decision in Case of Minerals Separation vs. Hyde. *Min. Mag.*, IX, 171 (1913). *Min. Sci. Pr.*, CVII, 270 (1913).

ANON.—Elmore Flotation Process. *Mex. Min. Jour.*, XVII, 432 (1913).

ANON.—Flotation at Great Cobar. *Min. Sci. Pr.*, CVI, 284 (1913).

ANON.—Flotation at Inspiration Mill. *Met. Chem. Eng.*, XI, 309 (1913).

ANON.—Flotation Processes. *Metall und Erz*, X, 242 (1913).

ANON.—Flotation Process for Silver Ores. *Min. Jour.*, CIII, 1081 (1913).

ANON.—Lyster Process of Selective Flotation. *Min. Mag.*, VIII, 317 (1913).

ANON.—Minerals Separation Suit against Hyde. *Eng. Min. Jour.*, XCVI, 317 (1913).

ANON.—Present Status and Possibilities of Minerals Separation Process. *Eng. Min. Jour.*, XCV, 271 (1913). *Min. Mag.*, VIII, 102, 340, 412 (1913). *Min. Sci. Pr.*, CVI, 96, 574 (1913); CVII, 175 (1913). *Min. Jour.*, CIII, 248 (1913).

ANON.—Selective Flotation at Broken Hill. *Min. Sci. Pr.*, CVII, 334 (1913).

ANDERSON, E.—Murex Process. *Min. Sci. Pr.*, CVI, 787 (1913).

BOUSQUET, G.—Flotation Processes. *Genie Civil*, LXIII, 196 (1913).

FALKENBERG, O.—Details of Treatment by Murex Process at Grund in Harz Mountains. *Min. Jour.*, C, 101 (1913).

MITCHELL, D. P.—Flotation of Zinc Corporation, Limited. *Rev. de Met. Extr.*, XXXIII, 164 (1913).

NEWMAN, J. M.—Selective Flotation at Broken Hill. *Austral. Min. Stand.*, June 26, 1913.

SMITH, H. H.—Detailed Description of Minerals Separation Plant at Kyloe, Australia. *Met. Chem. Eng.* XI, 131 (1913). *Min. Sci.*, LXVII, 203 (1913). From *Australasian Inst. Min. Eng.*, Sept., 1912.

SULMAN, H. L.—Froth Flotation Processes. *Met. Chem. Eng.*, XI, 53 (1913).

WALKER, E.—Flotation Patents, DeBavay and Minerals Separation Processes. *Min. Sci. Pr.*, CVI, 29 (1913).

Accessory Apparatus

ANON.—Behr Stamp Feeder. *Eng. Min. Jour.*, XCV, 854 (1913).

ANON.—Crib Ore Bin. *Eng. Min. Jour.*, XCVI, 451 (1913).

ANON.—Doe Run System of Handling Concentrates. *Eng. Min. Jour.*, XCV, 231 (1913).

ANON.—Dust Collector for Dry Concentrator. *Eng. Min. Jour.*, XCVI, 595 (1913).

ANON.—Reinforced Concrete Tailings Bin. *Eng. Min. Jour.*, XCVI, 305 (1913).

ANON.—Simple Pulp Distributor. *Eng. Min. Jour.*, XCV, 280 (1913).

BORCHERDT, W. O.—Weighing Mill Feed. *Eng. Min. Jour.*, XCVI, 77 (1913).

BOTSFORD, H. L.—A Timber Ore Pocket. *Eng. Min. Jour.*, XCV, 227 (1913).

IRVIN, D. F.—Adequate Sampling in Modern Gold Mill Practice. *Min. Sci. Pr.*, CVI, 514 (1913).

KENNER, A. R.—Shaking Pan Stamp Feeder. *Eng. Min. Jour.*, XCV, 423 (1913).

NICHOL, W. J.—Side Tip for Conveyor Belt. *Eng. Min. Jour.*, XCVI, 216 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 96 (1913). From *Min. Eng. Rev.*, 314 (May 5, 1913).

RHODES, W. B.—Air Lifts *vs.* Centrifugal Pumps. *Col. Sch. Mines. Mag.*, January, 1913. *Min. Sci.*, LXVII, 91 (1913). *Met. Chem. Eng.*, XI, 162 (1913).

RICE, C. T.—Helping Out Bucket Elevators. *Eng. Min. Jour.*, XCVI, 165 (1913).

SŒHNLEIN, M. G. F.—Dewatering Huntington Mill Feed. *Eng. Min. Jour.*, XCVI, 892 (1913).

VON BERNEWITZ, M. W.—Pumps, Tailings Wheels and Bucket Elevators for Elevating Pulp. *Min. Sci., Pr.*, CVI, 282 (1913).

WORCESTER, S. A.—Examples of Saving of Labor Costs in Mills especially by Mechanical Handling of Material. *Min. Sci., Pr.*, CVI, 481 (1913).

Mill Principles, Theory and General Ideas

ANON.—Improvements in Ore Dressing. *Zeit. f. Berg. Hütten. u. Salinenw. im Preuss.*, LXI, 196 (1913).

ANON.—Reducing Losses in Ore Dressing. *Eng. Min. Jour.*, XCVI, 942 (1913).

ALLEN, A. W.—Colloids in Ore Dressing. *Min. Sci. Pr.*, CVII, 109 (1913).

BARTSCH, W. J.—Ore Dressing Methods. *Stahl und Eisen*, XXXIII, 2035 (1913).

CAETANI, G.—Sand, Slime and Colloids in Ore Dressing. *Min. Sci. Pr.*, CVI, 438 (1913).

CAETANI, G.—The Human Side of Milling. *Min. Sci. Pr.*, CVII, 800 (1913).

ECCLESTON, C. W.—Ore Dressing and the Concentration of Ores. *Min. Eng. World*, XXXVIII, 445 (1913).

GOODALE, S. L.—Mill Physiology or Study of Mills in Operation. *Met. Chem. Eng.*, XI, 556 (1913). *Mex. Min. Jour.*, XVII, 581 (1913).

HERWEGEN.—Concentration of Fine Sands and Slimes. *Stahl und Eisen*, XXXIII, 2034 (1913). *Zeit. Verein. Deutsch. Ing.*, LVII, 2046 (1913).

HILLEBRAND, W. F.—Danger of Chemical Action in Use of Heavy Solutions for Testing Minerals. *Am. Jour. Sci.*, XXXV, 439 (1913).

LANG, H.—Planning and Laying Out Mills. *Min. Sci. Pr.*, CVII, 4 (1913). *Min. Mag.*, IX, 142 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 212 (1913).

LAUCKS, I. F.—Principles and Methods of Ore Testing. *Eng. Min. Jour.*, XCVI, 51 (1913).

MARSH, A. G.—Details of Systematic Lubrication at Steptoe Mill. *Eng. Min. Jour.*, XCV, 1237 (1913).

MEGRAW, H. A.—Calculation of Extraction in Gold Milling. *Eng. Min. Jour.*, XCVI, 441 (1913).

SHARWOOD, W. J.—Calculation of Extraction. *Eng. Min. Jour.*, XCVI, 937 (1913).

STEELE, H.—Percentages of Recovery from Porphyry Copper Ores. *Min. Sci. Pr.*, CVI, 865 (1913). *Min. Mag.*, IX, 63 (1913).

WELTON, W. S.—Calculation of Extraction in Concentration. *Eng. Min. Jour.*, XCVI, 75 (1913).

WIARD, E. S.—Tendencies in Concentration. *Met. Chem. Eng.*, XI, 237 (1913). From *Col. Sci. Soc.*

Examples of Practice—Gold and Silver Mills

ANON.—Bullfinch Proprietary Gold Mill, Australia. *Min. Sci. Pr.*, CVII, 217 (1913).

ANON.—Changes at Knights Deep Mill. *Eng. Min. Jour.*, XCV, 281 (1913).

ANON.—Consolidated Langlaate Mill, South Africa. *Met. Chem. Eng.*, XI, 417 (1913). From *So. Afr. Min. Jour.*, May 17, 1913.

ANON.—El Tajo Mill. *Mex. Min. Jour.*, XVI, 137 (1913).

ANON.—Flow Sheet of Palmarejo and Mexican Cyanide Mill. *Min. Sci. Pr.*, CVI, 115 (1913).

ANON.—Gold Milling in China. *Min. Sci. Pr.*, CVII 227 (1913).

ANON.—Gold Milling Progress in California. *Mex. Min. Jour.*, XVII, 596 (1913).

ANON.—Latest Designs in South African Mills. *Mex. Min. Jour.*, XVI, 299 (1913).

ANON.—McIntyre Mill at Porcupine, Ontario. *Min. Sci. Pr.*, CVII, 52 (1913).

ANON.—Milling Costs at Bodie, California. *Min. Sci. Pr.*, CVI, 521 (1913).

ANON.—New Shamva Mill in Rhodesia. *Min. Sci. Pr.*, CVI, 509 (1913). *Met. Chem. Eng.*, XI, 291 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 75 (1913). *So. Afr. Min. Jour.*

ANON.—Small Stamp Mills for Alaska. *Min. Eng. World*, XXXVIII, 739 (1913).

ANON.—Tigre Mill, Sonora. *Min. Sci. Pr.*, CVI, 702 (1913).

ANON.—Yuanni Mill, West Australia. *Eng. Min. Jour.*, XCV, 186 (1913). From *Monthly Jour. Chamber of Mines of W. Australia*, Oct. 31, 1912.

ALLEN, A. W.—Simplification of Gold Ore Treatment. *Min. Sci. Pr.*, CVII, 254 (1913).

ARGALL, P.—Cyaniding in 1912. *Eng. Min. Jour.*, XCV, 108 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 584 (1913).

BANKS, E. G.—Milling at Waihi Mine, New Zealand. *Australasian Inst. Min. Eng.*, XVI, 115 (1912).

BATES, B. R.—Treatment at El Rayo Mill. *Mex. Min. Jour.*, XVI, 39 (1913).

BELL, J. M.—Treatment of Gold Ore at Waihi, New Zealand. *Australasian Inst. of Min. Eng.*, XV, 548 (1911).

CARTER, H. F.—250-Ton Cyaniding Mill at Pozos, Guanajuato. *Informes y Memorias del Institute Mexicano de Minas y Metalurgia*, III, No. 2, 55 (1913). *Mex. Min. Jour.*, XVI, 285 (1913). *Met. Chem. Eng.*, XI, 348 (1913).

CLARK, A. J. and SHARWOOD, W. J.—Metallurgy of the Homestake Ore. *Inst. Min. Met.*, XXII, 68 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 330, 382, 575 (1913); XIV, 95 (1913). *Mex. Min. Jour.*, XVI, 230 (1913). *Met. Chem. Eng.*, XI, 105 (1913). *Eng. Min. Jour.*, XCV, 161, 215, 617 (1913).

COLBURN, E. A., JR.—Colburn-Ajax Mill at Cripple Creek. *Mex. Min. Jour.*, XVI, 231 (1913).

CONKLIN, H. R.—Lluvia de Oro Mill, Chihuahua. *Eng. Min. Jour.*, XCV, 551, 582 (1913).

DENNY, J. J.—Nipissing Low Grade Mill. *Min. Sci. Pr.*, CVII, 484 (1913). *Can. Min. Jour.*, XXXIV, 672 (1913).

DICKSON, G. F.—Cam and Motor Mill, Rhodesia. *Min. Mag.*, IX, 132 (1913). *Met. Chem. Eng.*, XI, 591 (1913).

DULIEUX, E.—Mills at Porcupine. *Bull. Soc. l'Ind. Min.* [V], IV, 121 (1913).

EDDY, L. H.—Hardenberg Stamp Mill, California. *Eng. Min. Jour.*, XCV, 502 (1913).

EMPSON, J. B.—Comparison of Concentration and Cyaniding with Direct Cyaniding on Pachuca Ores. *Informes y Memorias del Instituto Mexicano de Minas y Metalurgia*, III, No. 2, 86 (1913).

FORBES, D. L. H.—Dome Gold Mill at Porcupine. *Can. Min. Inst.*, XVI, 161 (1913).

FORBES, D. L. H.—El Tigre Mill, Sonora, Mexico. *Mex. Min. Jour.*, XVI, 186 (1913).

FYFE, A.—Waihi Grand Junction Gold Mill, Waihi, New Zealand. *Australasian Inst. Min. Eng.*, XVI, 62 (1912).

GOODALE, S. L.—Argo Cyanide Mill, Idaho Springs, Colorado. *Eng. Min. Jour.*, XCVI, 385 (1913).

GUILLET, L.—Progress in Metallurgy of Gold. *Mex. Min. Jour.*, XVI, 60 (1913).

HAFER, C.—Candor Gold Mill in North Carolina. *Min. Sci. Pr.*, CVI, 728 (1913).

HILLMANN, W.—Gold Milling Processes and Apparatus. *Metall und Erz*, X, 689 (1913). *Zeit. Verein. deutsch. Ing.*, LVII, 1643 (1913).

HOLCOMBE, J. P.—San Francisco Mill, Pachuca, Mexico. *Inst. Min. Met.*, XXII, 661 (1913). *Mex. Min. Jour.*, XVI, 294 (1913). *Met. Chem.*

Eng., XI, 349 (1913). *Eng. Min. Jour.*, XCV, 1104 (1913). *Can. Min Jour.*, XXXIV, 270 (1913). *Min. Eng. World*, XXXVIII, 911 (1913).

HORE, R. E.—Milling at Cobalt, Ontario. *Can. Min. Jour.*, XXXIV, 363, 402, 568 (1913). *Min. Mag.*, IX, 302 (1913).

HUBBARD, J. D.—Mill of Chosen Mining Company. *Min. Sci. Pr.*, CVI, 510 (1913).

HUNTOON, L. D.—Stamp Milling in 1912. *Eng. Min. Jour.*, XCV, 107 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 583 (1913).

JAMES, A.—Progress in Gold-Silver Ore Milling in 1912. *Mex. Min. Jour.*, XVI, 82 (1913). *Min. Sci. Pr.*, CVI, 23 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 579 (1913). *Min. Mag.*, VIII, 143 (1913).

JARMAN, A.—Milling at Talisman Mine, Karangahake, New Zealand. *Australasian Inst. Min. Eng.*, XVI, 339 (1912).

KENDALL, R. H.—Treatment of Refractory Low-grade Gold Ores at Ouro Preto, Brazil. *Mex. Min. Jour.*, XVII, 496 (1913). From *Inst. Min. Met.*, XX, 28 (1911).

KENNEDY, J. C.—Big Four Mill at Manhattan, Nevada. *Min. Sci. Pr.*, CVI, 824 (1913).

KENNEDY, J. C.—Manhattan Mill, Nevada. *Min. Eng. World*, XXXVIII, 859 (1913).

KIDDER, S. J.—Regrinding at the Pittsburg Silver Peak Mill. *Min. Sci. Pr.*, CVI, 306 (1913).

LAMB, R. B.—Treatment of Gold Ores. *Can. Min. Jour.*, XXXIV, 214 (1913). *Mex. Min. Jour.*, XVI, 246 (1913).

LETCHER, O.—New Gold Milling Plants in Rhodesia. *Min. Sci. Pr.*, CVII, 761 (1913).

LETCHER, O.—South African Mills. *Min. Eng. World*, XXXVIII, 17, 107, 302, 435, 493, 767, 1189 (1913).

MANDY, J. T.—Milling at Cobalt. *Min. Jour.*, C, 61 (1913).

MARTIN, A. H.—Gold Milling Progress in California. *Met. Chem. Eng.* XI, 640 (1913).

MCMIKEN, S. D.—Komata Reefs Mill, New Zealand. *Met. Chem. Eng.*, XI, 53 (1913).

MEGRAW, H. A.—Analysis of Cyanide Milling. *Eng. Min. Jour.*, XCV, 110 (1913). *Jour. Chem., Met. Min. Soc. So. Afr.*, XIII, 630 (1913).

MEGRAW, H. A.—Black Oak Cyanide Plant, California. *Eng. Min. Jour.* XCV, 1179 (1913).

MEGRAW, H. A.—Cyanidation at Cripple Creek. *Eng. Min. Jour.*, XCV, 313 (1913).

MEGRAW, H. A.—Cyanide Practice in Canadian Fields. *Can. Min. Inst.*, XVI, 146 (1913). *Min. Eng. World*, XXXVIII, 811 (1913).

MEGRAW, H. A.—Cyanide Practice in the Black Hills. *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 499 (1913). From *Eng. Min. Jour.*, XCIV, 1221 (1912).

MEGRAW, H. A.—Cyaniding at Grass Valley, California. *Eng. Min. Jour.* XCV, 983 (1913).

MEGRAW, H. A.—Cyaniding the Ores at Republic, Washington. *Eng. Min. Jour.*, XCV, 835 (1913).

MEGRAW, H. A.—Dome Mill, Porcupine District. *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 433 (1913). From *Eng. Min. Jour.*, XCIV, 983 (1912).

MEGRAW, H. A.—Gold Road Cyanide Mill, Arizona. *Eng. Min. Jour.* XCVI, 3 (1913).

MEGRAW, H. A.—Grinding Ores for Cyanidation. *Eng. Min. Jour.*, XCVI, 821, 917 (1913).

MEGRAW, H. A.—Hollinger Gold Mill, Porcupine. *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 496 (1913). From *Eng. Min. Jour.*, XCIV, 1175 (1912).

MEGRAW, H. A.—Mills at Tonopah. *Eng. Min. Jour.*, XCV, 413, 455, 503, 534 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 16 (1913).

MEGRAW, H. A.—Nevada Hills Mill. *Eng. Min. Jour.*, XCV, 645 (1913).

MEGRAW, H. A.—Nevada Wonder Mill. *Eng. Min. Jour.*, XCV, 693 (1913).

MEGRAW, H. A.—Tom Reed and Vulture Mills, Arizona. *Eng. Min. Jour.*, XCVI, 199 (1913).

MORSE, E. C.—San Poil Mill at Republic, Washington. *Am. Inst. Min. Eng., Bull.* No. 73, Jan., (1913), p. 79. *Met. Chem. Eng.*, XI, 162 (1913).

PALMER, L. A.—Wasp No. 2 Mill, South Dakota. *Min. Sci.*, LXVII, 103 (1913).

PARMELEE, H. C.—Gold Milling in the Black Hills, *Met. Chem. Eng.*, XI, 395, 435, 500 (1913).

PARMELEE, H. C.—Ophir Mill, Colorado. *Met. Chem. Eng.*, XI, 25 (1913).

PARSONS, A. R.—Crushing Tonopah Ores. *Eng. Min. Jour.*, XCV, 1110, (1913).

RANDALL, J.—Cyanide Practice in United States and Mexico. *Mines & Minerals*, XXXIII, 391 (1913).

REID, F.—Milling at Cobalt, Ontario. *Can. Min. Jour.*, XXXIV, 542, (1913). *Min. Sci. Pr.*, CVII, 216 (1913).

RODGERS, E. C.—Mother-lode Mill, Salmo, B. C. *Eng. Min. Jour.*, XCVI, 529 (1913).

ROGERS, R. B.—New York and Honduras Rosario Mill. *Min. Sci. Pr.*, CVI, 472 (1913).

SCHMITT, C. O.—Treatment of Stamp Battery Residue. *Eng. Min. Jour.*, XCVI, 1023 (1913).

SILL, H. A. and R. T. —Zambona Silver Cyanide Mill. *Eng. Min. Jour.*, XCV, 745 (1913).

SIMMONS, J.—Homestake and Wasp Mills, South Dakota. *Min. Mag.*, IX, 47 (1913).

SIMMONS, J.—Milling in the Black Hills, South Dakota. *Min. Eng. World*, XXXVIII, 11, 757, 849, 1051 (1913); XXXIX, 9, 115, 255 (1913).

SIMONDS, E. H.—Milling by Coarse Crushing in Cyanide Solution. *Mex. Min. Jour.*, XCI, 135 (1913). *Jour. Chem. Met. Min. Soc. So. Afr.*, XIV, 27 (1913). *Met. Chem. Eng.*, XI, 291 (1913).

STONE, S. R.—Brakpan Mines, South Africa. *Min. Eng. World*, XXXIX, 1100 (1913).

THOMPSON, F. A.—Ore Treatment at Republic, Washington. *Am. Inst. Min. Eng., Bull.* No. 73, Jan., 1913, p. 51. *Min. Sci.*, LXVII, 87, 105 (1913).

VON BERNEWITZ, M. W.—McNamara Mill at Tonopah. *Min. Sci. Pr.*, CVI, 182 (1913).

WATSON, R. B.—Nipissing High Grade Mill at Cobalt. *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 493 (1913). From *Eng. Min. Jour.*, XCIV, 1077, (1912).

WESTON, E. M.—Rand Mining and Milling Costs. *Eng. Min. Jour.*, XCV, 329, 425 (1913).

WITTICH.—Brakpan Mill at Johannesburg. *Metall und Erz*, X, 934 (1913).

WOOD, W. M.—Vulture Gold Mill, Arizona. *Min. Sci. Pr.*, CVII, 1018 (1913).

Examples of Practice—Concentrating Mills

ANON.—Butte & Superior Mill. *Mines & Methods*, IV, 101 (1913). *Min. Sci. Pr.*, CVI, 952 (1913).

ANON.—Canada Ore Dressing Laboratory. *Eng. Min. Jour.*, XCV, 1046 (1913). *Min. Eng. World*, XXXVIII, 1039 (1913). *Can. Min. Jour.*, XXXIV, 301 (1913).

ANON.—Concentration at Lake Superior Copper Mines. *Min. Mag.*, VIII, 145 (1913). From *Met. Chem. Eng.*, X, 795 (1912).

ANON.—Concentration of Lead Zinc Ores. *Metall und Erz*, X, 261 (1913).

ANON.—Concentration of Low-grade Iron Ores of Tennessee. *Min. Eng. World*, XXXIX, 1157 (1913). From *Bull.* No. 16, *State Geologists' Report, Tennessee.*

ANON.—Electrical Equipment at the Ohio Mill. *Min. Sci. Pr.*, CVI, 214 (1913).

ANON.—Handling Material in Lake Superior Rock Houses. *Eng. Min. Jour.*, XCV, 947 (1913).

ANON.—Lead Mill of Vieille Montagne Zinc Company. *Inst. Min. Eng.*, XLVI, 149 (1913).

ANON.—Mill of St. Lawrence Pyrites Company. *Min. Sci. Pr.*, CVI, 551 (1913).

ANON.—Mill Practice in 1912. *Min. Sci. Pr.*, CVI, 7 (1913).

ANON.—Morning Mill and Bunker Hill and Sullivan Mill in Idaho. *Min. Eng. World*, XXXIX, 967 (1913).

ANON.—Preparation of Foundry Sand. *Zeit. Verein. deutsch. Ing.*, LVII, 1062 (1913).

ANON.—Sapphire Concentration. *Eng. Min. Jour.*, XCVI, 389, (1913).

ANON.—Tailing and Ore Treatment by Zinc Corporation at Broken Hill. *Min. Sci. Pr.*, CVII, 104 (1913).

ANON.—Tin Dressing at Rooiberg, South Africa *Min. Mag.*, VIII, 451 (1913). From *So. Afr. Min. Jour.*, April 19, 1913.

ANON.—Tin Dressing in the Transvaal. *Min. Jour.*, CI, 494 (1913).

ADENEY, T.—Concentrating at Great Fitzroy Copper Mines. *Australasian Inst. Min. Eng.*, XV, 136 (1911).

BRYANT, F. C.—Washing Barite in Missouri. *Eng. Min. Jour.*, XCV, 317 (1913).

CLIFFORD, J. O.—Miami Copper Mill. *Mines & Methods*, IV, 115 (1913).

COWLES, R. K.—Tin Dressing in Cornwall. *Jour. Chem. Met. Min. Soc. So. Afr.*, XIII, 503 (1913). From *Min. Sci. Pr.*, CV, 730 (1912).

DICK, W. J.—Washing for Diamonds. *Can. Min. Inst.*, XVI, 289 (1913).

EDWARDS, E.—Tin Sluicing in Tasmania, *Australasian Inst. Min. Eng.*, XV, 267 (1911).

FALKENBERG, O.—Treatment of Tinstone and Wolframite. *Min. Jour.*, CII, 815 (1913).

FISCHER, S.—Concentration of Carnotite Ores. *Am. Electrochem. Soc.*, XXIV, 361 (1913). *Min. Sci.*, LXVIII, 259 (1913).

FLAGG, A. L.—Concentrating High-grade Fines by Hand. *Eng. Min. Jour.*, XCVI, 69 (1913).

FLAGG, A. L.—Lawrence Mill in Kootenai County, Idaho. *Min. Eng. World*, XXXVIII, 340 (1913).

GOODALE, S. L.—Milling in Clear Creek and Gilpin Counties, Colorado. *Eng. Min. Jour.*, XCVI, 195 (1913).

GRAVES, W. H.—Progress in Colorado Milling. *Min. Eng. World*, XXXVIII, 713, 853 (1913).

HANSELL, N. V.—Concentrating Iron Ore. *Min. Mag.*, VIII, 141 (1913). From *Am. Inst. Min. Eng. Bull.* No. 72, 1497, 1565 (Dec., 1912).

HARNICKEL, W.—Concentration of Spathic Iron. *Stahl und Eisen*, XXXIII, 1735 (1913).

HILLS, V. G.—Concentration of Scheelite. *Met. Chem. Eng.*, XI, 22 (1913). *Min. Sci. Pr.*, CVI, 448 (1913).

HOWARD, L. O.—Ore Dressing at Yellow Pine Mine, Nevada. *Salt Lake Min. Rev.*, XIV, No. 21, 12 (1913). *Min. Eng. World*, XXXVIII, 1009 (1913).

LLOYD, S. L.—Phosphate Ore Dressing. *Mines & Minerals*, XXXIII, 333 (1913).

MERCER, H. T.—Rock House Practice of Copper Range Company, Michigan. *Can. Min. Jour.*, XXXIV, 372 (1913). From *Lake Superior Min. Inst.*, XVII, 283 (1912).

MILLER, B. L.—Concentrating Graphite in Pennsylvania. *Min. Eng. World*, XXXVIII, 625 (1913).

MOORE, R. B. and KITHIL, K. L.—Concentration of Uranium and Vanadium Ores. *U. S. Bureau Mines Bull.* No. 70, 35 (1913).

MUNROE, H. S.—Progress in Ore Dressing. *Min. Sci. Pr.*, CVI, 56, 101 (1913).

NORTHEY, G. V.—Concentration of Cinnabar Ores. *Eng. Min. Jour.*, XCVI, 783 (1913).

ORTIN, M. T.—Concentration of Gold Silver Lead Copper Ore at Blagodatny Works. *Metall und Erz*, X, 799 (1913).

PALMER, L. A.—Milling Tungsten Ore in Colorado. *Eng. Min. Jour.*, XCVI, 99 (1913).

PARSONS, C. S.—Jigging Plant for Iron Ore at Torbrook, Nova Scotia. *Can. Min. Inst.*, XVI, 608 (1913).

PULSIFER, H. B.—Wisconsin Zinc Mills. *Min. Eng. World*, XXXIX, 69, 109 (1913).

REITZENSTEIN.—New Lead-Zinc Mill in Kreutte at Bleiberg. *Dingl. Polytech. Jour.*, CCCXXVII, 779 (1912).

RITTER, E. A.—Rico Mill, Colorado. *Min. Eng. World*, XXXVIII, 895 (1913).

ROESLER, H. A.—Single Jig Mills in Wisconsin Zinc District. *Eng. Min. Jour.*, XCV, 785 (1913).

SEBENIUS, J. U.—Concentrating Mesabi Iron Ores. *Lake Superior Min. Inst.*, XVIII, 155 (1913). *Iron Age*, XCII, 452 (1913).

WILSON, A. W. G.—Pyrites Milling. *Can. Min. Jour.*, XXXIV, 219, 236 (1913).

WITTICH, L. L.—Recovering Brass from Foundry Cinders. *Eng. Min. Jour.*, XCV, 853 (1913).

WOOD, H. E.—Concentration of Pitchblende. *Eng. Min. Jour.*, XCV, 1164 (1913).

WRIGHT, C. A.—Concentrating Zinc Ore in Joplin District. *U. S. Bureau of Mines, Tech. Paper* No. 41 (1913).

WOODBRIDGE, D. E.—Low-grade Iron Ores and Their Beneficiation. *Min. Eng. World*, XXXVIII, 705 (1913).

Treatment of Coal

ANON.—Balanced Shaking Screen. *Coal Age*, III, 676 (1913).

ANON.—Coal Preparation in Eastern Kentucky. *Coal Age*, III, 670 (1913).

ANON.—Coal Washing Plant at Baruch. *Coll. Guard.*, CVI, 993 (1913).

ANON.—Improvements in Coal Washing. *Zeit. f. Berg. Hütten u. Salinen. im Preuss.*, LXI, 198 (1913).

ANON.—Jeffrey Single-roll Crusher. *Coal Age*, IV, 306 (1913).

ANON.—Mason & Allen Slate Picker. *Coal Age*, III, 766 (1913).

ARCHBALD, H.—Preparation of Anthracite. *Coal Age*, III, 673 (1913).

BRACKETT, F. E.—Screening Bituminous Coal. *Coal Age*, III, 130 (1913).

BUCHANAN, G.—Preparation of Coal. *Coal Age*, III, 750 (1913).

DAVENPORT, F. B.—New Buttonwood Anthracite Washery in Pennsylvania. *Coal Age*, III, 554 (1913).

HALL, R. D.—Coal Preparation in Franklin County, Illinois. *Coal Age*, III, 719 (1913).

LANGERFELD, A.—Methods and Machines for Cleaning Coal. *Coal Age*, III, 685 (1913).

MOEHRLE, TH.—Modern Methods of Coal Sludge Recovery. *Compt. rend. Soc. l'Ind. Min.*, 94, 346 (1913). From *Oesterr. Zeit.*, LX, 340, 358 (1912).

MOLINGHEN.—Briart Balanced Coal Screens. *Annal. des Mines de Belg.*, XVIII, 1102 (1913).

MUELLER, F. E.—Coal Washery at Soddy, Tennessee. *Mines & Minerals*, XXXIII, 295 (1913).

NEUMANN, R., and R. BLUMENFELD.—American Coal Jigs. *Zeit. Verein. deutsch. Ing.*, LVII, 896 (1913).

PRICE, W. Z.—Short Mountain Anthracite Breaker. *Coll. Eng.*, XXXIV, 267 (1913).

ROGERS, J. D.—Preparation of Kentucky Coal. *Coll. Eng.*, XXXIII, 426 (1913).

SELTNER, W.—Trifail Coal Washery. *Oesterr. Zeit. f. Berg. und Hütten.* LXI, 253, 267, 284 (1913).

WILLIAMS, M. J.—Crushing Coal for Coking. *Coal Age*, III, 683 (1913).

HYDRO-METALLURGY OF COPPER IN 1913

By Thomas T. Read

At present keen interest prevails in wet methods for the extraction of copper from its ores, arising from the necessity for devising some means to recover the copper present in the form of oxidized minerals in the enormous tonnages of low-grade ores now being mined and milled in many different places. The oxides, carbonates, and silicate of copper are all rebellious both to ordinary wet concentration and to flotation, and the use of hydro-metallurgical processes seems the only possible means of effecting the recovery of their copper content. The general criteria of the hydro-metallurgy of copper have been discussed at some length on several occasions,[1] and need no further references. All the most promising of recent work has centered around leaching in sulphuric acid solution. The simplest method, to be applied on the largest scale, is that proposed for the brochantite ore of the Chile Copper Co., Chuquicamata. This has already been described at some length,[2] but may be summarized by saying that careful large-scale experimental work done by E. A. C. Smith has demonstrated that the copper content of this hydrous sulphate of copper can be extracted by leaching the ore, after crushing to 3-mesh, with 8 or 9 per cent. sulphuric acid solution. This is to be done in concrete vats holding 9000 tons each, and it is estimated that one day will suffice for filling, two or three days for leaching and washing, and one day for discharging, which is to be done with clam-shell buckets. The copper in the pregnant solution will be precipitated electrolytically, a 40,000-kw. generating station on the seacoast and a 100-mile transmission line being already under construction. This ore contains no gold, silver, bismuth, arsenic, or antimony and, being a sulphate, the solution builds up in sulphuric acid, so that acid consumption is *nil*. Small amounts of chlorides and nitrates are present and cause difficulties which have been successfully overcome.

Leaching work at the Braden has been delayed by more urgent problems, and the necessity of using the available electric energy for other purposes. E. A. C. Smith has recently described[3] the proposed process as follows: "The process decided on was roasting of the concentrate in a

[1] Wet Methods of Copper Extraction, Editorial, *Min. Sc. Pr.*, Sept. 21, 1912; Sulphuric Acid Leaching, Editorial, *Min. Sc. Pr.*, Aug. 16, 1913; Leaching of Copper Ores, John Rooke-Cowell, *Min. Sc. Pr.*, Aug. 23, 1913; Copper Leaching, *Eng. Min. Jour.*, Jan. 10, 1914, p. 101.
[2] Leaching of Copper Ores in Chile, Editorial, *Min. Sc. Pr.*, June 21, 1913.
[3] *Bull. Min. Met. Soc.*, Nov., 1913.

Wedge furnace in such a manner as to eliminate practically all of the sulphur and at the same time oxidize all the iron to the ferric state. The concentrate, after roasting, contained 2 to 3 per cent. sulphur, practically all in the form of sulphate, 15 to 18 per cent. copper, and about the same amount of iron of which only a very small amount was present in the ferrous state. The roasted concentrate was leached with dilute sulphuric acid, and the leaching operation being divided into two stages: first, neutralizing leaching; second, acid leaching. The solution from the neutralizing leaching was electrolyzed direct, whereas the solution from the acid leaching was neutralized by the following batch of calcines. Several leachings made in the plant indicate an extraction of between 90 and 95 per cent. of the copper present in the concentrate."

The most interesting announcement of the year[1] was that roasting and leaching with sulphuric acid, following a method devised by Frederick Laist, was to be tested on a large scale for treating the tailing from wet-concentration processes at Anaconda. An 80-ton experimental plant was constructed, and the results of the first work were published[2] during the summer. As this paper is readily accessible and contains many important details, it should be read by all. Briefly, the process consists in drying the tailing from wet concentration on the upper hearths of a MacDougall roaster, adding salt, and roasting at a low temperature to keep down the volatilization of copper chloride and the production of ferrites. The calcine is then leached with sulphuric acid solution. Experimental work later in the year has been highly successful. It was at first proposed to precipitate the copper from this solution by H_2S, thus regenerating H_2SO_4, but more recent work indicates the desirability of using an iron sponge produced by reducing 20-mesh calcine with coal dust in a reverberatory furnace. The sulphuric acid required for leaching is to be made in lead chambers, from the SO_2 gas obtained in roasting rich coarse concentrate, at an estimated cost of $4 per ton. Tentative plans for a 2000-ton plant are well advanced. As a result of the success of this work experiments along similar lines are being made at several places. Later work has shown that better results are obtained by delaying the addition of salt until leaching has begun, as the decrease in silver extraction is less than the roasting losses thus avoided.

P. E. Peterson[3] has published descriptions of the Butte-Duluth and Bullwhacker plants, which were erected at Butte last year. It is to be deplored that these descriptions do not include any account of the numerous difficulties encountered in the early operation of these plants,

[1] Editorial, *Min. Sc. Pr.*, May 3, 1913.
[2] Roasting and Leaching Tailings at Anaconda, Frederick Laist, *Bull. A. I. M. E.*, July, 1913.
[3] *Min. Eng. World*, Sept. 6 (p. 423) and Oct. 4 (p. 585), 1913.

as being more helpful to operators elsewhere than the methods found successful. These plants operate under special conditions, in that they treat siliceous ore comparatively free from the iron oxides present in ordinary oxidized ores. The Butte-Duluth plant is 100-ton and the Bullwhacker 125-ton. At the Butte-Duluth the ore was at first crushed, by gyratory and Symons disk crushers, only through a 1/2-in. screen. The 1/2-in. ore was dumped into V-shaped leaching vats, provided with a filter bottom of boards bored with 5/8-in. holes. After leaching with acid, the vats were discharged through doors in the bottom. The solution is drawn from the vats, allowed to settle, elevated to lead-lined tanks, where it is heated to 60° C., and thence to the electrolytic cells. Each of these is 30 by 39 in. and 8 ft. long, lined with hard lead, and provided with 20 anodes of hard lead, weighing 20 lb. per square foot. The cathodes are ordinary starting sheets of copper. The current density used is 12 to 13 amp. per square foot, and the cathodes assay 99.96 per cent. copper, according to Mr. Peterson. The present cost is estimated by him as 14 cents per pound of copper, but he thinks this can be considerably reduced, as the sulphuric acid required now costs $27 per ton or 4 3/4 cents per pound of copper produced. If locally manufactured on a large scale, the sulphuric acid should not cost over 1 1/2 cents per pound of copper.

The percentage of extraction on the 1/2-in. ore was so low by the method described by Mr. Peterson that it was later found necessary to abandon it, and the following modified process has now been adopted. The Company is building a 1000-ton dry-crushing plant to reduce the ore to 10 mesh. This consists of a swing-jaw crusher, intermediate gyratory crusher, Symons disk crusher, rolls, and impact screens. The dry ore is fed to a mixer with approximately four times its weight of 8 to 10 per cent. sulphuric acid which discharges to a Dorr classifier. which is the first of a series of 6 arranged in such a manner that the sand will discharge from one into the next. Various times of contact with the acid in the first four Dorr classifiers were tried out and it was found that approximately 40 minutes gave an extraction between 85 and 90 per cent. The last two classifiers, No. 5 and 6, in the series, are used for washing. The overflow from No. 5 is used to make up for the loss of acid in the strong acid solution.

The overflow from No. 1 classifier carries off approximately about 13 per cent. of the total weight of ore as slime. This, as well as the overflows from classifiers 2, 3, and 4 are run to the acid-leaching tanks in the bottom of which is a layer of crushed ore to act as a filter. The underflow from these filters passes to the electrolytic cells and on to the strong acid storage-tanks where the solution is brought up. This

method of running the slime to the acid leaching-tanks is only temporary as later on it is intended to recover the dissolved copper content by passing this pulp through a series of Dorr continuous thickeners operated so as to give counter-current washing.

The second wash water, which is applied to the last classifier, goes to scrap iron precipitation. The sand discharged from the classifiers approximates 18 to 20 per cent. moisture. No. 1 classifier in the series is a machine 30 ft. long by 4 ft. 6 in. wide. The rest of the classifiers are of standard duplex size, 15 ft. long by 4 ft. 6 in. wide. These machines are built with wooden boxes and all moving parts that come in contact with the acid are also built of wood (hard maple). The wear of the wooden teeth is surprisingly small, but the experiments have shown that plate glass teeth are the proper ones to use here, and will be installed in any future classifiers built for this purpose. This series of 6 classifiers is operating at the present time and has a capacity of approximately 200 to 220 tons per 24 hours.

The Dorr Cyanide Machinery Co. is building another series of 5 machines each 30 ft. long by 8 ft. wide, which should have a capacity of 400 to 500 tons of ore per day. At the present time strong acid solution is being added with the ore to No. 1 classifier, but later on this practice will be altered and the overflow from No. 5 Dorr classifier will be mixed with the dry ore; the advantage of this being that the strong solutions can be kept from coming in contact with the slime, the weak acid solution not taking iron and aluminum into solution so readily as the strong. All solutions in the plant are kept at approximately 55° C. The cost of this in the northern winter climate is likely to form a considerable item of the total working cost.

The leaching of the Butte-Duluth ores in Dorr classifiers gave such favorable results that another machine was added to the first series, making seven in all, and a second line of large classifiers, each 30 by 8 ft. wide is now being installed. The whole of the slime and solution from these machines will be run to acid proof Dorr thickeners, the clear overflow passing to the electrolytic cells and the thick underflow being washed with barren solution and water.

Walter H. Weed has made[1] the following statement regarding the operations at this plant: "The mill feed for the past six months has averaged 2.01 per cent., copper. * * * The ore passes through the leaching machine in 32 1/2 minutes and 88 per cent. of the copper content is extracted by the solution. The consumption of acid is 67 1/2 lb. of 60 per cent. sulphuric acid per ton of ore. No trouble is experienced from fouling of the solution, the constant accession of first-wash water and of

[1] *Min. Eng. World*, Feb. 21, 1914, p. 377.

fresh acid diluting the amount of iron and alumina. The solution is returned to the machine after settling in tanks until it contains 3 to 4 per cent. copper and 9 to 19 per cent. acid. It is then pumped to the electrolytic cell room, where the copper content is recovered on cathode sheets.

"The waste solutions and wash waters are sent to the concentration plant and copper content recovered as cement copper. The output of the plant in January, 1914, was 55,000 lb. of electrolytic and about 40,000 lb. of fine copper in the form of cement copper.

"The estimated costs of mining and treatment given herein are based on figures taken from the company's records. The plant has been so much bettered in the past few weeks and the present treatment, with lowered costs, has been in operation so short a time that the figures given must be accepted as a reliable estimate, and not as a record of actual experience for the past year. The present cost, using both leaching tanks and the leaching machine, is $3 per ton of ore. The present plant is treating a little more than 100 tons per day, the total tonnage in January amounting to 3200 tons of ore. I firmly believe very material improvement made by Mr. Sherwood in the cell room and the taking out of the rectangular leaching tanks will reduce the costs, even with the present plant, to $2.70 per ton of ore treated."

At the Bullwhacker plant, which is near by, the ore, crushed to 16 mesh, is agitated with 10 per cent. H_2SO_4 solution, 2 tons of solution to 1 of ore, in a Hendryx agitator. The effluent solution, containing as much as 4 to 5 per cent. copper, is decanted from settling tanks, and sent to electrolytic cells which differ from those previously described in being circular, 9 ft. in diameter and 5 ft. deep, holding 24 cathodes. About half of the copper content of the solution is deposited electrolytically, and it then goes back to be used for further leaching. The cost of production of copper is here also about 14 cents per pound.

The difficulties of the method employed in these two mills are, perhaps not unnaturally, not discussed at length. They may be summarized as follows: fine crushing is necessary in order that the copper minerals shall be completely soluble, but leads to the production of colloids ("slime") which make the solution cloudy and difficult to settle. It is, of course, impossible to deposit a pure cathode from a solution containing many impurities. The leached ore is difficult to wash for the same reason, and also because the use of wash water involves the discharge of solution, which carries away with it not only the expensive sulphuric acid but copper as well. This copper can be precipitated on iron, but the consumption of iron by the acid cuts down the net return. The difficulties and excessive consumption of energy in precipitating copper electrolytic-

ally when using an insoluble anode are too well known to need repetition. Here the resistance of the solution has been decreased by preheating it, and its conductivity is kept as high as possible by precipitating only half of the copper present. At several other mines, notably the Nevada-Douglas, preparations are being made for the construction of similar plants, but it is not to be expected that these can be put into operation without first solving local problems.

At nearly every important copper mine in the West some member of the chemical or metallurgical staff is studying hydro-metallurgical problems in the light of local conditions. Much work is being done upon the oxidized ores of the Calumet and Arizona, but has not reached the state where any public statement can be made. The work at the Shannon was described last year, and no reports of progress have since been given out. The Arizona Copper Co. will probably adopt a modification of the Bullwhacker plant. At the Keystone and Inspiration, both at Miami, interesting work is being done. J. Parke Channing has described this work in the *Bulletin* of the Mining and Metallurgical Society of America. R. S. Canby, at the Keystone, suggests the possibility of using cast-iron hearths as at the Steptoe Valley smelting plant, in the MacDougall roasting furnaces, so that the fuel used on one hearth would better heat those above. He proposes to use a special design of burner which will permit the use of oil as a fuel along with the maintaining of a low temperature on the hearth. The research for the Inspiration is being done at the Laboratories of the University of Pittsburgh, and at the same place E. R. Weidlein has devised a process in which SO_2 passed into the hot pregnant solution under pressure precipitates Cu. The proposed process is fully described in the specifications for U. S. patent 1089096, and a test plant is in process of construction at Wabuska, Nevada, where the Metals Research Co. (W. B. Thompson interests) will give it a thorough trial. At the Copper Queen the leaching of low-grade ores is also being studied; indeed, almost every chemical laboratory in the country contains one or more investigators.

W. Y. Westervelt has described in some detail, in the November *Bulletin* of the Mining and Metallurgical Society, the results of a 33-day test with the Siemens-Halske process on the average ore at the Ray mine in Arizona. This is of much interest, since at the Bwana M'Kubwa mine it was proposed to use the Siemens-Halske process, presumably in much the same form, but this process has now been dropped, and the Mackay process will be tried. The Bradley leaching plant at Anaconda has closed down, having proved a failure. The various other patented processes seem not to have made much headway during the year. The Mackay process, which is now being developed by

Archibald Carmichael, was under investigation by important interests, but negotiations have been dropped. The owners of the Alexander process are carrying an experiments, but have made no report of progress. The same may be said of the Robertson process. The Irving process has been described by L. S. Austin,[1] and the Slater Process has been described by H. W. Morse.[2] The leaching of the copper contained in the burned cinder from sulphuric acid making is being done in a number of places, but is quite a different operation from the leaching of raw or roasted ore. In the precipitation of copper from mine-water, J. W. Richards has suggested that if the scrap iron used for this purpose were laid upon sheets of copper, a galvanic couple would be established and the surface of the iron kept cleaner and consequently more efficient. It has been proposed to use sponge iron for this purpose in place of the usual scrap iron, but the experiment has not yet been made. In conclusion, it may be said that the experimental work at Anaconda has demonstrated the possibility of roasting sulphide tailing at a low cost, and the leaching plants at the Bullwhacker and Butte-Duluth have demonstrated the practicability of sulphuric acid leaching and electrolytic precipitation for oxidized siliceous ores, with prospects of attaining a low cost. It must not be forgotten, however, that local conditions create fresh problems at each mine, while the problem of treating slime has hardly been attacked.

[1] *Min. Sc. Pr.*, Jan. 3, 1914.
[2] *Min. Sc. Pr.*, Jan. 24, 1914.

THE ANALYSIS OF SMELTER CONTRACTS[1]

By Gelasio Caetani

The smelting industry, like any other commercial industry, has only one object, and that is to derive profit from its operations. The smelters figure on a certain net profit per ton of ore treated, and base their profits on a rather complicated system of discounts and charges. Producers generally claim that the smelters rob them in every possible way; the smelters protest, stating that all they claim is a fair interest on the capital invested in their plant. The truth of the whole matter is that the buying and selling of ores is a commercial transaction in which both of the two parties are supposed to look out for themselves. The smelters have always a clear knowledge of how much profit they are going to make on every transaction, because they know exactly how much of the metals will be recovered and how much it will cost them to smelt the ore. The producers, on the other hand, are in most cases entirely ignorant of this and generally complain of being "held up" in a shameful manner. I will attempt to analyze this much-debated question and to point out how much can be asked and how much should be expected from the producer's point of view. Smelters will probably find fault with what I am going to say.

The Smelter's View Point.—The profits of a smelter are chiefly dependent upon a large volume of business and on low operating costs. The volume of business is instrumental in keeping down overhead charges and capital interest per ton of ore treated; the cost of reduction is minimized by purchasing ores of different kinds in such proportions that their mixture will be self-fluxing; in addition to this, the by-products of one part of the plant can generally be re-treated advantageously in some other part of the plant.

Individual mining companies can but seldom avail themselves of all these advantages. It is infrequent for the ore of any one mine to be self-fluxing, nor is the tonnage available commonly sufficient to operate a smelter with economy. Individual mining companies are therefore unable, in most cases, to compete with local custom smelters, and are obliged to accept the smelter schedules, even if these are excessively onerous.

[1] A lecture delivered at Harvard University. From *Mining and Scientific Press.*

The smelting companies in purchasing ore must charge the producers with the total costs of smelting, capital interest, metal losses, refining charges, and so forth, in addition to their own profits. At the same time, they must protect themselves against sudden variation in the market price of the metals on account of the large stocks they have to carry on hand either in the form of ore or of bullion. To cover all these charges the smelters could adopt a simple method of discounts and charges; but probably such plain and simple figures would look more distressing to the average producer than they do appear when presented in the form of a complicated network of deductions, discounts, penalties, bonuses, smelting charges, and so forth. It therefore takes some mathematical knowledge and a good business head to see daylight through the wording of a smelter contract.

Smelters are always willing to purchase any ore on the market at moderate prices. However, they cannot depend for continuous operation on the willingness of others to sell; they must be assured of receiving, within reasonable limits, a constant and sure supply of each of the ingredients required to make up the furnace charges, and it is natural, therefore, that more favorable terms are given to such producers as can assure a constant supply of ore and will bind themselves for a considerable length of time.

As the Mine Operator Sees It.—On the other hand, the mine operator, while endeavoring to obtain good terms, must take care not to be tied down too closely. He must first of all make provision to share in the increase or decrease of profit resulting from the rise or fall of the market price of metals. Provisions for this are made in most of the contracts, though generally the smelting companies reserve for themselves the lion's share of the good harvest that may come in when metal prices are booming.

A fundamental flaw in many contracts is the absence of any provision by means of which the producer will share the profits that may be derived in the future from improved metallurgical processes, lowered freight rates, or better transportation facilities. In our times, metallurgy is advancing so rapidly that in a few years conditions may have changed completely. Let us suppose that a mine manager has signed a 10-year contract to deliver all the products of his mine to a certain lead smelter. As the mine development progresses the ore becomes more and more zincy, and, according to the terms stipulated in the contract, he is penalized for its zinc content above 10 per cent. This zincy ore, let us suppose, could be treated successfully by some new process that would separate the zinc as a merchantable product, but this cannot be done as, according to the smelter contract, all products of the mine must be de-

livered to the smelter. Provision must also be made for any possible reduction of freight rates when the cost of transporting the ore from the mine to the smelter is included in some general smelter charge; otherwise, when the freight rates are reduced, all the benefit of such reduction goes to the smelting company. It must also be kept in mind that the metallurgical processes may improve so much in a few years, or competition may become so keen, that the smelter is enabled or obliged to offer better rates in the open market, and it is only fair that the old customer, tied down by a long-term contract, should share in these improved conditions.

In purchasing ore the smelting companies cover themselves by making deductions from the content of the ore, discounts on the market price of the metals, general charges for smelting and refining, and by penalizing any deleterious substance. Bonuses and payments for iron and manganese are given to encourage shipment of low-grade ores and to increase the iron supply to the smelter. I shall now analyze the various items.

Discounts and Deductions.—Discounts and deductions are virtually the same thing, and can always be summed into a single discount. A contract may be so framed as to read: "The smelter will pay for 90 per cent. of the lead content at 90 per cent. of full market quotation." This is exactly the same as if it read "The smelter will pay for 81 per cent. of the lead content at full market quotation." Notwithstanding that smelter contracts are always full of such intricacies, it is most important to know when and to what extent discounts are justified, and this subject deserves detailed analysis.

To begin with, the smelting losses in gold are practically *nil.* In many cases, even in pyritic smelting, the smelter recovery on gold is over 100 per cent. The reason of this is that many lead and copper ores contain a few cents in gold per ton of ore; these minute quantities are saved in smelting with no more difficulty than the gold of the high-grade ores, but no account is taken of them in the furnace charge because no payment is made for gold contents below 0.03 or even 0.05 oz. per ton. The value of gold never changes, and there is no risk whatever connected with the fluctuations of metal prices; the smelters therefore rely in great part on the gold and silver discounts as a safe source of profit, and generally put up a hard fight against any reduction in these items. These discounts are generally on a sliding scale; that is, $19 per ounce is paid for low-grade ores; $19.50 for ores containing from 1.5 to 3 oz., and generally $20 for gold contents above 3 oz. per ton. Recently some smelting companies have been paying $19.50 for any content above 0.03 oz., per ton, and $20 for contents above 3 oz., and these are to be considered the best terms obtainable under ordinary conditions. At these figures the gold discounts amount to 5.5 and 3.2 per cent. Though these discounts are

not heavy, they represent a large source of profit, as in many cases the preponderating value of ores lies in their gold content.

The discount on silver is almost always the same, whatever be the kind of ore under consideration, and as a rule is 5 per cent. of the silver content at full market valuation. In lead smelting the silver loss is generally under 3 per cent., whereas in pyritic and in copper smelting in general it can be at times as high as 10 per cent.; for this reason some contracts for copper ores call for a 10 per cent. discount on the silver content. High-grade silver ores, like those from Cobalt, are at times heavily discounted, these discounts on the silver taking, to a certain extent, the place of the treatment charge. Zinc, arsenic, and antimony will increase silver losses by volatilization, but provisions are made for this by penalizing the deleterious substances without further discounting the silver.

Many contracts stipulate that no payment be made for silver contents when less than 1 oz. The smelter seems to give the impression that this is a negligible quantity. On the other hand, it is by no means a negligible quantity, as fully 95 per cent. of it will be recovered in smelting. In some districts, as in the San Juan district in Colorado, the gold and silver are intimately associated with the blende, and therefore zinc concentrates will carry as high as $20 in gold and silver. In the roasting and retorting of the blende there is a notable mechanical and volatilization loss of the precious metals. The zinc smelters take advantage of this and inflict outrageous discounts on the precious metals. A 43 per cent. discount on the contents is a common practice. Some zinc-reduction plants offer another arrangement. After the zinc has been distilled from the concentrate the retort residue is held at the disposal of the producer, and is shipped as gold-silver-iron ore, according to his instructions. It is generally stated that the zinc smelter will use "his best efforts to recover the largest possible amount of these values in the residue." In the case I have in mind, these best efforts succeeded in losing 41 per cent. of the gold and 35 per cent. of the silver. To avoid such losses, every endeavor should be made to recover as much as possible of the precious metals from the zinc concentrate before selling it to the smelter.

Payment for Lead.—The discounts on lead vary widely from one district to another, as these discounts are always figured out in connection with the treatment charges; when the treatment charges are low, the discounts on lead are heavy, and *vice versa*. In the Coeur d'Alenes, for an instance, the total discounts on lead in the high-grade lead concentrates produced in that district will range from 19 to 22 per cent. and the treatment charges range from $8 to $12 per ton. In Colorado, instead, the discounts on lead in the high-grade gold and silver-bearing lead con-

centrates will vary from 35 to 50 per cent., but at the same time the treatment charges will range from $2 to $3.50 per ton. In this case, as in many other instances, the various items of a smelter contract are so arranged as to balance each other; the sole object of the smelter is to make a certain profit per ton of ore treated, and it is immaterial to the smelter whether this profit be derived from discounting the metals, or raising the treatment charges, or penalizing the silica or some other substance. At times a producer will insist on especially good terms on some particular item; generally the smelters are very accommodating in this; all they do is to raise the charge on some other item. Some of these concealed "jokers" are mentioned later on.

Calculating the Real Charge.—This balancing between the lead discounts and treatment charges makes it difficult to calculate and compare the deductions made on the lead. In the Coeur d'Alene district, where the ores do not carry other values than lead and silver (about 0.6 oz. of silver for every unit of lead), the average total of charges and deductions is 1.93 cents per pound of lead when the market value of lead is $4.25. The producers are therefore paid only for 66 per cent. of the gross market value of *all* merchantable metals contained in the ore, and as this gross value for the whole district averages close to $57, it means that the smelters make a total average discount of $19.40 to cover all their metallurgical losses, costs, interest, and profits.

The metallurgical losses of lead will range from 3 to 10 per cent. and will average not over 5, so that the customary discount on lead contents alone is more than ample to cover all metallurgical losses. To this must be added the old and time-honored "joker" of dry assay; that is, a deduction of 1.5 units from the wet assay of lead. For high-grade ore this additional deduction does not amount to much, but in low-grade ores, assaying say 20 per cent. lead, this deduction represents an additional discount of 7.5 per cent. Another source of profit for the smelters is the non-payment for lead contents below 5 per cent. lead, dry assay. Ores containing very low percentages of lead are called "dry" ores and are used as iron or silica fluxes in the making up of the lead-furnace charge. This furnace charge is always figured out to contain a certain percentage of lead varying from 15 to 20, and it is immaterial whether the lead, which is the collecting agent for the gold and silver, be included in the dry ore or added as a high-grade lead concentrate.

Formulæ for Making Comparisons.—To be able to compare a lead schedule with another is not an easy matter. The following rule of thumb method makes it possible, however, to judge in a general way whether a schedule is favorable or not: Take the lead content of the ore and multiply it by the net unit price paid for by the smelter. Then

subtract the treatment charge. The ratio of this difference to the gross market value of the lead content of the concentrate is equal to the percentage of values received from the smelter. Written algebraically it would read:

$$\frac{\text{Pb content} \times \text{net price} - \text{treatment}}{\text{Pb content} \times \text{market price}} = \text{per cent. profit}$$

If this percentage is above 65 per cent., the schedule is very good; if around 60 per cent., it is good; and if below 55 per cent., it is a poor one. In using this rule of thumb take care, however, that a "joker" is not hidden somewhere else.

Payments on copper are almost always based on the content as determined by electrolytic assay less a certain number of units varying from 0.85 to 2 and this price is based on the New York quotation for electrolytic copper less a discount varying from 2 to 8 cents per pound. Most contracts for copper ores call for electrolytic assay less 1.3 units at New York quotation less 2.5 to 3 cents, with an additional treatment charge of $3 to $5 per ton.

Applying to copper ores the same rule of thumb given for the lead ores, it will be found that on an average (when copper is at 15 cents) a 10 per cent. copper ore is paid for at 56.5 per cent. of its gross market value, and a 20 per cent. ore is paid for at 68.2 per cent. of its gross value. The copper schedules are therefore not much better than the lead schedules. A good "copper joker" is generally found for the ores that, though containing some copper, are not sold chiefly for their copper content. The smelters try to make you believe in an off-hand way that the small amount of copper in your ore is really not worth mentioning. If the mine operator is aware of the real value of the copper he will generally succeed in getting paid for the electrolytic assay content less 1.3 units at New York quotation less 5 cents. If not aware of this, he may be offered nothing more than electrolytic assay less 2 units at the flat rate of $1 per unit, though at such a price of copper as 17 cents, 2 units of copper have a gross value of $6.80. Percy E. Barbour, in a valuable article,[1] gives full information on copper smelter settlements.

Zinc Penalties.—The zinc in any ore other than the ores mined especially for their zinc content, is a nuisance. By this I mean that any ore, the leading values of which are gold, silver, lead, or copper, is depreciated by the presence of zinc minerals, even if the zinc minerals are eventually separated and sold as a zinc concentrate. This statement, though not universally true, generally holds good for any ore that will not yield by wet concentration a concentrate assaying above 30 per cent. zinc. There are three reasons for this: (1) Some zinc mineral will always pass into

[1] *Eng. & Min. Jour.*, August 12, 1911.

the mill products that are not shipped as zinc concentrates and often will cause them to be penalized for excess zinc content; (2) the treatment of the ore becomes more expensive, the cost of separating the zinc by some dry process varying from $1.50 to $2.50; (3) and not least, the value of the gold, silver, lead, and copper contained in the zinc concentrates is very heavily discounted, as stated previously.

Against all these penalties and losses is to be credited the net paid-for value of the zinc, which in most cases amounts to about 40 cents per unit when spelter sells at 6 cents in St. Louis. On this basis a lead-gold-silver ore containing 5 per cent. zinc and which will yield 60 per cent. of its zinc as zinc concentrate (this is a high figure) is to be credited with $1.20 per ton crude ore for its zinc content, and the total operating costs, losses, and penalties to be debited against the zinc will most certainly greatly exceed this figure.

Western Base Price.—Zinc concentrates are sold on a base-price schedule. A characteristic example for Western ores is as follows: A base price of $22 is paid for a 45 per cent. zinc concentrate delivered f. o. b. Oklahoma when spelter sells at 5 cents per pound. For every plus or minus variation of 1 cent in the price of spelter there is added or subtracted $6 to the base price of $22. So also for every unit of zinc above or below 45 per cent., there is added or subtracted $1 to the base price. In Missouri schedules are based upon 60 per cent. zinc contents.

In all other ores but zinc ores, the presence of this metal is deleterious. A high zinc content in the blast-furnace charge will call for a heavier fuel consumption, it will cause a marked loss of lead and silver by volatilization, and the thickening of the slag is a further cause of losses and annoyances. If, however, the zinc content of the slag is kept below 6 per cent., the operation of the blast-furnace is not disturbed to any appreciable extent. In some mining districts the zinc content of the ores is low, and the local smelters are not bothered in the slightest degree by zincy slags. Notwithstanding this, the smelter will never fail to call for a 50 per cent. zinc penalty on every unit in excess of 10 per cent. In such a case this is not a penalty, but simply an indirect way of increasing the treatment charge. An operator who is aware of local circumstances and cannot be bluffed by this "zinc joker" has a good argument for putting up a hard bargain and generally will succeed in reducing the zinc penalty to 25 cents for every unit above 12 per cent.

Iron and Silica.—Both iron and silica are required for smelting, and they are required in certain definite proportions, and when either the siliceous or the iron ores are in preponderance on the market, the smelter is obliged to offer special inducements for the kind of ore which is needed. The supply of siliceous ores is stimulated by reducing the treatment charges

and that of iron ores by paying for the excess of iron above insoluble. In the Coeur d'Alenes the gangue of the lead concentrates consists chiefly of iron carbonate, and the per cent. insoluble is always very low. Notwithstanding this, no payments or bonuses are made for iron, whereas in other districts the smelters will pay anywhere from 5 to 15 cents for each unit excess iron. In this case, therefore, as in the one previously mentioned for the zinc, a thorough knowledge of the ore-market condition will enable a mine operator to obtain a better deal. Manganese has the same function as iron in the fluxing of ores, and, though frequently not mentioned in contracts, ought to be always credited to the same extent as iron.

The so-called "insoluble" is a general term covering everything that will not dissolve in strong concentrated acids and in no way represents the silica content of the ore. Mr. Barbour, in his before-mentioned article, is of the opinion that contracts ought to call for silica determination by fusion. Most smelters would object to this, the reason being that many ores contain basic silicates due to the walls or to intrusions in the vein, and the base radical of these silicates has to be fused without assisting the fluxing of the ore. More so, frequently ores carry barite, which is not only useless but also deleterious.

Lime is advantageous and even necessary in blast-furnace operations unless the charge be very zincy; as lime-bearing ores are comparatively rare, the smelters are usually obliged to obtain barren limestone from some quarry. Therefore, lime is just as valuable to them as iron, and they ought to pay equal prices for both these fluxes. This ought to be kept in mind and payments asked for the lime content of ores.

Zinc, barium, arsenic, and antimony are considered deleterious substances in most ores; sulphur (and frequently also phosphorus) is objectionable in iron ores; lime and magnesia in zinc ores; and even silica, nickel, and other substances may be considered deleterious under special circumstances. The analysis of all these substances would lead too far into the field of fire metallurgy and, being of comparatively rare occurrence and secondary importance, in western ores, can be omitted for the present.

Ores and concentrates, with the exception of iron ores, are settled on the basis of dry ore. The moisture, therefore, does not affect the treatment charge, but only the freight charge, it being taxed by the railroad companies at the same rate as the ore. Each per cent. moisture therefore is taxed at the rate of 1 per cent. of the freight charge per ton of ore. When freight rates are low and the ore comparatively dry, the charge on moisture is negligible, but in localities where freight rates are high it often pays to dry the concentrates.

In the Lake Superior district, iron ores are sold on the basis of "natural iron"; that is, on the per cent. of iron contained in a ton of wet ore. The unit prices are on a sliding scale; that is, a 50 per cent. iron natural ore is paid at 5 cents per unit, whereas a 46 per cent. iron natural is paid only 3½ cents per unit. In this case the drying or draining of an iron ore raises the natural grade of the ore. As an example, if a 46 per cent. iron natural containing 9 per cent. moisture be dried to 3 per cent. moisture, the grade of the ore would be raised to 49.1 per cent. iron natural, with a resulting profit of 41 cents per ton.

Importance of Moisture Determination.—In many cases the smelters will give a flat freight and treatment charge per ton of dry ore. In such case the per cent. of moisture in the ore does not affect the shipper, but the smelter is generally willing to lower its flat rate if the shipper guarantees to keep the moisture below a certain limit.

Settlements are generally based on the weight and moisture determinations made by the smelter. These determinations must be controlled by the producer, and it is well to specify this point in the contract, because an incorrect determination of either moisture or weight is just as objectionable, at a financial point of view, as an incorrect assay.

This review of the unit prices and deductions can be taken as a guide in gaging to what extent the terms of a smelter schedule are advantageous to the producer or the smelter. As already mentioned, these terms must not be gaged entirely by themselves, but always in connection with all other factors affecting the final net return per ton of ore. Any bonus or extra charge, the treatment charge, the freight rates to the smelter, all of these items influence one way or the other toward the final economic return, and any especially good term on some specific item must be considered as offsetting to some extent some other item which may appear unduly disadvantageous.

Bonuses

The object of bonouses is to offset some charges which would be too severe on some ores if applied indiscriminately to all ores. They also stimulate the production of certain especially desirable kinds of products. As an example: smelters will often grant bonuses on ore assaying below a certain value, and thereby induce the producer to ship low-grade material (as, may be, the concentrate of a canvas plant) which otherwise would necessarily have been thrown to waste. The bonuses or reduced treatment charges, on the other hand, are also used to stimulate the production of very high-grade concentrates which, owing to their high metal content, can be shipped to some distant point at a less cost per

pound of metal than otherwise would be possible. More generally, however, the smelters take special pains to increase rapidly the percentage of their profit as the value of the ore increases, relying on the basic principle that the larger the melon, the less bashful you must be in helping yourself. In this the railroad companies are close seconds. Sometimes these progressive charges are discontinuous; a $20 ore will pay $5 treatment charge per ton, a $30 ore $6, and so forth, the other charges and per cent. discounts remaining the same.

Typical Smelting Contracts.—On lead concentrates a very usual progressive unit price schedule is as follows: 90 per cent. of the lead is paid at 90 per cent. of the New York quotation if said quotation is less than $4.10; if the quotation is above $4.10, then the smelter will pay 90 per cent. of the lead at 90 per cent. of $4.10 plus one-half the difference between $4.10 and the market quotation. This schedule makes a progressive charge as the price of lead increases, reserving to the smelter the lion's share when metal prices are booming. Figured out on this basis the total lead deductions are:

Price per 100 lb.

	Per cent.
$4 total deduction	19.0
5 total deduction	25.5
6 total deduction	30.3

On copper ores the per cent. of deduction varies in the opposite direction, becoming smaller as the market price increases. This condition exists notwithstanding that the market fluctuations of the price of copper are more capricious than those of lead. It may be one way of making the lead producers pay for tariff potection.

All these various aspects of the smelter contract question are so disparate, so complex, and often so contradictory that it is quite possible you may understand them less now than you thought you did before I started. This happens quite often when you go deeply into a subject.

It may help to resort to graphical representation, and it is quite remarkable to note of how much assistance diagrams are, in comparing the relative value of various smelter schedules, in disclosing the hidden jokers, and in conveying definite suggestion as to how to modify mill operation in view of realizing the maximum economic efficiency.

Graphical Studies.—As an example of graphic representation I have prepared here two sets of diagrams. In the first one (Fig. 1) are drawn the diagrams of three smelter contracts for lead ores which are actually in force in Western states. In figuring out these diagrams I have omitted payments for gold, silver, copper, and iron, as the addition of these

payments would complicate matters. The diagram therefore simply gives the net value per ton of ore f. o. b. the mine for varying lead contents of the ore. The value per ton of ore will also vary according to the market value of lead, and therefore there are three variables to be represented on the diagram, that is: value per ton, grade of ore, and market value of

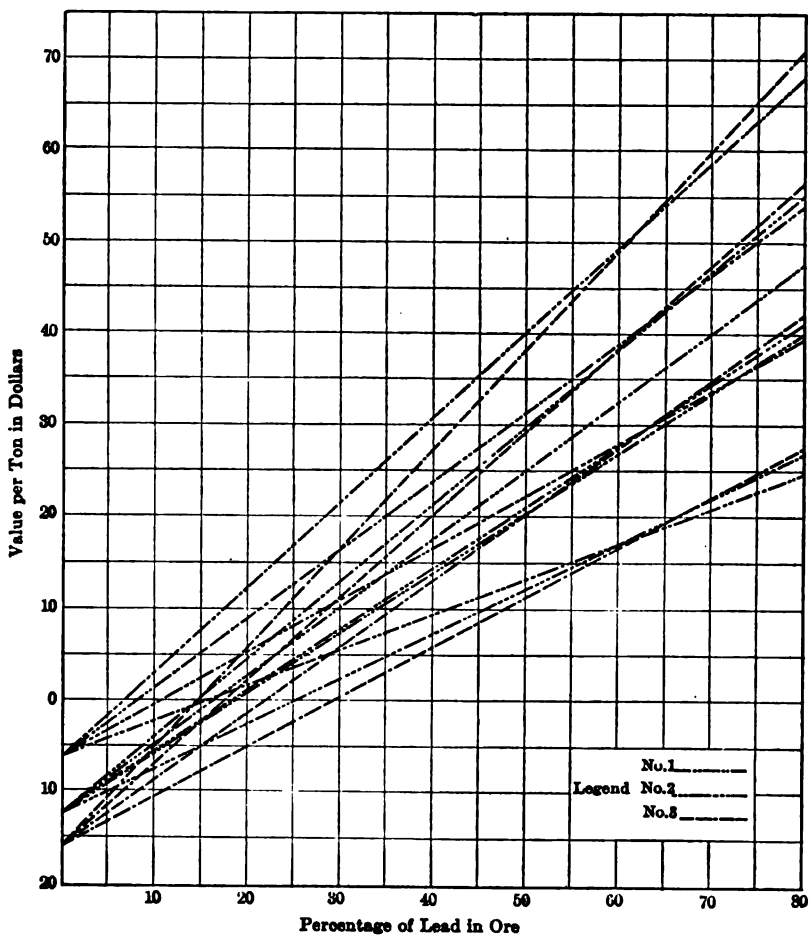


FIG. 1.

lead. To represent these three variables, curves may be used as shown on Fig. 1. The vertical divisions correspond to value per ton in dollars; horizontal divisions to percentages of lead in ore. The diagrams represent a schedule reading as follows:

No. 1. The smelter will pay for 90 per cent. of the lead at full New

York quotations less 1¼ cents per pound of lead; the treatment charge to be 10 cents for every unit of lead below 60 per cent., and there will be a bonus of 10 cents for every unit of lead above 60 per cent.

No. 2. The second schedule reads as follows: The smelter will pay for 90 per cent. of the lead content at 90 per cent. of the New York quotation if this quotation is less than $4.10, and if above $4.10 it will pay at the

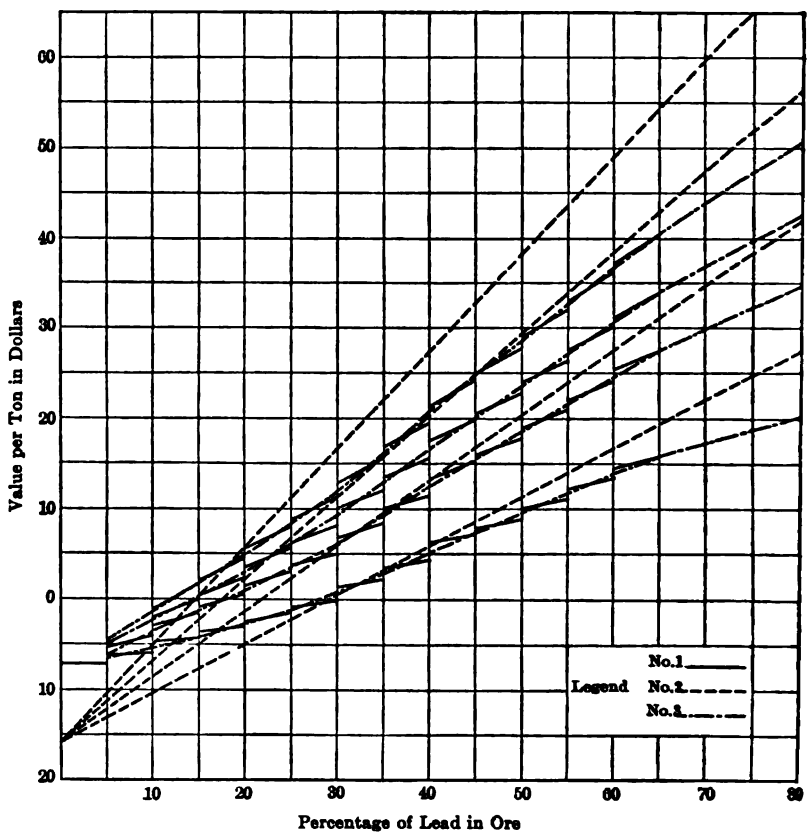


FIG. 2.

rate of $3.69 per 100 lb. plus one-half the difference between the New York quotation and $4.10. Treatment charges to be $12.25 per ton.

No. 3. The third schedule calls for payment on 90 per cent. of lead content at full New York quotations less $15.75 per ton.

In Fig. 2, I have reproduced the lines representing the value of the ore under the three schedules when the price is $4 per 100 lb., omitting all the other lines which at first glance make the diagram somewhat confusing.

Relative Advantages of Each Contract.—Looking at these diagrams, it will be seen that the No. 1 contract is more advantageous to the producer than either of the two others as long as the grade of the ore is below 63 per cent. lead. For ore higher than 63 per cent. the third schedule is more advantageous than the first one because though the treatment charge is heavier the price per unit of lead is highest. The second schedule is more advantageous than the third one for ores assaying less than 52 per cent. lead; it is less advantageous than either of the other two for ores ranging from 52 to 63 per cent., and again becomes more advantageous than schedule No. 1 for concentrates assaying above 73 per cent. lead. This means that if we can divide by concentration the ore into two classes, that is, into a concentrate assaying less than 63 per cent. lead and one above this grade, it will pay to do so, as by selling each product under the most favorable contract more profit will result than if the whole product were sold under any one single schedule.

To make this clearer, I must point out the fact that whenever a schedule is a linear function of the lead content, that is, when it is represented by a straight line on the diagram, there is no advantage whatsoever in producing concentrates of different grades. This is easily demonstrated by algebra. If, however, a schedule, or a combination of two or more schedules, represented graphically, appears as a curve or a polygonal line, concave on its upper side, then it is always profitable to divide the concentrate in two or more products of different grade. *Vice versa*, if a schedule appears on the diagram as a curve convex on the upper side, then there is always a possibility of determining a certain grade of concentrate at which the maximum price is obtained for every unit of lead.

Another important observation brought out by these diagrams is the minimum grade of the concentrate that can be shipped under any of the three schedules. Looking at Fig. 2, it will be noted that the schedule lines cross the zero line of the ordinates, respectively, at 12, at 19, and at 22. This means that any pound of material contained in the concentrate and which assays less than 12 per cent. lead is shipped at a loss if sold under schedule No. 1. To be sold under schedule No. 2 no part of any concentrate must assay less than 19 per cent. lead, and in the case of schedule No. 3, this limit is 22 per cent. lead.

I will illustrate this further. Suppose that all mill products must be sold under schedule No. 3, and that 100 tons of table concentrate assaying 50 per cent. lead are to be sold. From the diagram it may be seen that this is worth $20 per ton net. By running this concentrate over a cleaning table, 10 tons of tailing assaying 15 per cent. lead may be eliminated, giving at the same time 85 tons of a refined concentrate assaying 53.9 per

cent lead. The diagram shows that this 15 per cent. lead tailing, if shipped with the concentrate, would have represented a loss of $2.50 per ton. The operation of cleaning 100 tons of concentrate therefore has resulted in a net profit of $25. It may seem a shame to throw away 15 per cent. lead tailing, but if it pays to do so it must be done. If instead of selling under schedule No. 3 the concentrate was sold under schedule No. 1, the diagram shows that the 15 per cent. lead tailing is worth $2.50 per ton. It is useless to attempt to refine the concentrate unless it is possible to eliminate a tailing assaying not more than 12 per cent. lead.

The diagram also gives the net loss suffered in shipping barren material mixed with the concentrate. This loss is representd by the negative ordinate of the origin of the family of curves and is minus $6 for the No. 1 schedule, $12.25 for the second, and $15.75 for the third schedule. Suppose that the ore contains some barren barite which finds its way into the concentrate. If by some process, say the flotation process, it is possible to eliminate this barite there would be a profit corresponding to the figures given above.

Now going back to the diagram, Fig. 1, it appears that for schedules No. 1 and No. 3 the increase in value of the ore is directly proportional to the increase of the market price. For schedule No. 2 the case is different because, on account of the unit price being based on one-half of the difference between $4.10 and the New York quotation, the rate of increase becomes about one-half as soon as the market price of lead passes beyond $4.10. In fact, for lead $4 per hundred pounds, the difference between schedule No. 1 and No. 2 is only $2 for a 50 per cent. concentrate, whereas when lead is $6 this same difference is over $10. Therefore, schedule No. 2 is especially disadvantageous when the price of lead is high.

Colorado and Idaho Schedules.—The smelter schedules so far considered are represented by straight lines. Fig. 2 also gives the diagram of a lead schedule for gold-silver-lead ores, which is actually in use, in Colorado. The wording of the contract is too complicated to be given here, and it suffices to say that the unit price for each grade of ore is determined by adding or deducting 1 cent from a base unit price for every cent variation plus or minus a nominal market quotation which is obtained by discounting in a complicated way the true New York quotation for lead. The schedule being discontinuous, the diagrams are represented by a series of steps. The curves shown in Fig. 2 give an idea of the average value of the schedule. For comparison I have superposed on these curves the straight line diagrams of the same schedule, No. 3 which has been previously analyzed. This goes to show how far less advantageous the Colorado schedule is when compared with No. 3 schedule.

This is true for any high-grade ore. If, however, the ore or the concentrate produced were to be classed as "dry," that is, ores very low in lead, the Colorado schedule would be more advantageous, especially when the market price of lead is low. The difference is about $5 for ores assaying 10 per cent. lead in favor of the Colorado schedule, whereas the difference is about $7 in favor of the No. 3 schedule for concentrate assaying 60 per cent. lead and when the market price is $5 per 100 lb. This goes to prove how circumstances may change the relative value of two smelter schedules.

A further and more detailed analysis of smelter contracts would lead too far. The general review made will suffice to give an idea of the general plan on which are based the smelter contracts and of the great importance attached to the real understanding and to the mathematical analysis of this intricate subject.

THE NEW INTERNATIONAL DIAMOND CARAT OF 200 MILLIGRAMS [1]

By George Frederick Kunz

The manifold inconveniences resulting from the absence of a uniform standard of mass for determining the weight of precious stones have long been obvious. This lack has been keenly felt in commercial transactions, and those who have devoted time and research to the study of historic diamonds and precious stones have had frequent occasion to deplore the absence of such a standard in the past.

In a paper read in Chicago in 1893, before the International Congress of Weights and Measures, held in connection with the World's Columbian Exposition, the writer suggested dividing the carat into 100 parts, and constituting a standard international carat of 200 mg.; that is, 5 diamond carats or 20 pearl grains to a French gram, making 5000 carats or 20,000 pearl grains to a kilogram. He also called attention to the fact that while this would depreciate the present diamond carat or pearl grain only about 2.5 per cent., it would abolish the troublesome discrepancies between the various carat-weights now in use, and could be easily explained and understood everywhere.[2]

The subject of the various diamond carats, their incongruity, and the resulting confusion as to the correct weights of historic gems when definite records of them are searched for, has been fully treated by me in an extensive study of this subject in "The Book of the Pearl."[3]

To the earnest and unremitting efforts of C. E. Guillaume, Director of the Bureau Internationale des Poids et Mesures at Sèvres, is largely due the eventual success of this eminently desirable reform, which he has constantly urged both by articles on the subject and by addresses delivered in Paris before the International Committee for Weights and Measures.[4]

The general adoption of a uniform standard for dealings in precious stones, based upon a carat of 200 mg., was early recognized to be a result much to be desired, and great progress has recently been made in this direction. The carat has heretofore varied in weight in the different countries, with more or less resulting confusion and inconvenience to

[1] *Trans. Am. Inst. Min. Eng.*, LXVI, 1913.
[2] See "The Book of the Pearl," by George Frederick Kunz and Charles H. Stevenson, p. 325 New York, 1908).
[3] *Ibid.*, pp. 321–329.
[4] See C. E. Guillaume, Les récents progrès du système métrique; reprint from Vol. XV of "Travaux et Mémoires du Bureau Internationale des Poids et Mesures," pp. 62–66 (Paris, 1907).

business. The metric carat has now been formally adopted in most of the countries of Europe, and its use made compulsory. Our own country has at last taken favorable action, as has Great Britain also. Many of our dealers and importers recognize the theoretical advantage and the convenience of the change, but they apparently fail to take any active interest in it, as a practical reform. There can be little question, however, that the change must come ere long. A single standard for all countries, and the substitution of decimal for common fractions in the carat, are advantages so plain that they must surely soon be realized.

A striking illustration of the defectiveness of the system hitherto in use, as compared with the proposed new standard, is given in a recent article by L. J. Spencer, of the British Museum, on The Larger Diamonds of South Africa.[1] In this article an effort is made to clear up certain published errors and misstatements as to the great diamonds obtained in recent years from the African mines. But it proved impossible to ascertain definitely the precise weights of some of these notable stones, especially those of the earlier discoveries, on account of the uncertainty as to which carat-weight had been employed in determining them. The metric equivalent of the present "Board of Trade carat" is 205.304 mg.; while that of the old English carat, in use prior to 1888, was 205.409 mg. Hence, with some of the stones, only an approximate statement of their original weight is now possible.[2]

A first step in the direction of simplifying the carat-weight was taken in 1871, when the syndicate of Paris jewelers, goldsmiths, and others dealing in precious stones proposed the adoption of a carat of 205 mg. (3.1636 gr.) to take the place of the older French carat of 205.5 mg. (3.17135 gr.); this action was confirmed in 1877. On Oct. 17, 1890, the Association of Diamond Cutters of Antwerp fixed the value of the carat at 1 kg. = 4875 carats, which gave a carat of 205.183 mg., or 3.16561 gr. troy.

The more radical and effective change to the carat of 200 mg. was the subject of a resolution passed in January, 1906, by the Chambre Syndicale de la Bijouterie, Joaillerie et Orfèvrerie de Paris, and the Chambre Syndicale des Négociants en Diamants, Perles, Pierres Précieuses et des Lapidaires de Paris, and the reform was strongly advocated by M. Guillaume, in 1906, before the Commission des Instruments et Travaux. Shortly before, in the early part of 1905, the German Federation of Jewelers had petitioned the Imperial government to legalize the carat then in common use as a standard weight, but this was refused as in violation of the law prescribing the exclusive use of the metric system.

[1] *Mineralogical Magazine*, Vol. XVI, No. 74, pp. 140 to 148 (London, Oct., 1911).
[2] G. F. Kunz, Precious Stones during 1911; reprint from THE MINERAL INDUSTRY, Vol. XX, pp. 624, 625.

In the course of the discussion aroused by this refusal, M. Guillaume advocated the new international carat of 200 mg. as a possible solution of the difficulty, and as early as April, 1905, this proposition was taken into consideration by the International Committee. In August, 1906, on the motion of Ludwig Schröder, the following resolution was adopted by the German Federation: "Considering that it is both necessary and advantageous to replace the old carat by the metric carat of 200 mg., the Federation authorizes its president to approach the Imperial government and the foreign associations in order that the metric carat may be introduced as soon as possible in all countries."

Following the action of the International Committee, on Dec. 7, 1906, the Chamber of Commerce of Antwerp promised to rescind the resolution of Apr. 29, 1895, approving the adoption of a carat of 205.3 mg., as soon as the new international carat of 200 mg. should come into universal use in the markets. About the same time the Association of Jewelers and Goldsmiths of Prague formally authorized the German Federation to propose in its name the reform of the old carat as soon as possible by international agreement, and the Association of Goldsmiths of Copenhagen declared its willingness to support such a measure. The Belgian Committee of Weights and Measures, in July, 1907, declared its willingness to petition the government to legalize the new carat on its adoption by the more important countries.

In England and its colonies the proposed change was favorably received. In September, 1907, a resolution indorsing the new carat was passed by the Association of Manufacturing Jewelers of Melbourne, Australia; on Oct. 16, 1907, the Association of Societies for the Protection of Commerce in the United Kingdom passed a resolution urging its adoption in all countries, and on Jan. 23, 1908, the Birmingham Jewelers' and Silversmiths' Association gave expression to the hope that all nations would speedily accept an international carat of 200 mg.

The new carat has now been legalized in a number of countries; in others, laws favoring it are in course of preparation, or of adoption. Definite information has reached us concerning the legal status of the new international carat in the following lands:

Germany.—In the German Empire the question of the carat has been very simply settled, without any new legislation. The fifth article of the law of May 17, 1856, abrogated the carat in common use, which was not referred to in the laws of Aug. 17, 1868, and of May 30, 1908. Now while in most countries not only is the use of non-metric unities prohibited, but also any nomenclature foreign to that of the metric system, the laws of the German Empire are silent in regard to this latter particular. Hence those interested can give the name "carat" to the unity they commonly

use without coming in conflict with the laws, on the sole condition that this unity be represented by a standard figuring in the table of standards of mass subject to verification.

In conformity with the legal stipulation officially communicated by the Secretary of the Interior to the General Federation of German gem-dealers and jewelers, the Secretary has decided to adopt the new carat.

Belgium.—The draft of a law, signed by the King, was submitted to the Chambers at the beginning of July, 1909. This law has not yet been promulgated.

Bulgaria.—The new carat was included in the provisions of a law published Apr. 10, 1910.

Denmark.—The first article of a law voted Apr. 1, 1910, and which became operative on that day, is couched in the following terms:

"In the application of the metric system to the commerce in precious stones, pearls, etc., the metric carat, equivalent to 200 mg., shall henceforth be used."

Spain.—A Royal Order of Mar. 11, 1908, has prescribed the use of the new carat of 200 mg.

France.—The law of June 22, 1909, comprises a single article, as follows:

"In the transactions relating to diamonds, pearls, and precious stones, the designation 'metric carat' may, in violation of the first article of the law of July 4, 1837, be given to the double decigram.

"The use of the word 'carat' to designate any other weight is hereby prohibited."

Thus the new French law formally prohibits the use of the old carat, but admits that of the new international carat of 200 mg., considered to be an authorized violation of the fundamental law on the application of the metric system. The prohibition regarding the old carat was to become effective from Jan. 1, 1911, but owing to the difficulty of preparing the proper weights at so short notice, the request of the jewelers that a postponement should be granted until Jan. 1, 1912, was accorded; since that time the law has been operative.

This law was elaborated in two decrees, of July 7 and of Dec. 13, 1910. The first of these decrees stipulates that "the form of the carat-weight shall be that of a quadrangular, truncated pyramid, or of a cylinder surmounted by a knob. However, the carat-weights of less than 1 grm. are to be in the form of square-cut metal plates. The dimensions of the cylindrical weight shall differ from those established for such weights by the fifth appendix to the ordinance of June 16, 1839.

"The various weights are to be inscribed in intaglio and in legible

characters, the number of grams on the lower face; that of the metric-carats, followed by the abbreviation C. M., on the upper face."

The same decree enumerates the carat-weights constituting the minimum complete series with which the dealers interested must provide themselves; this series is in conformity with the metric system, between 2 mg. and 100 g.

Holland.—The law defining and legalizing the carat of 200 mg. was laid before the Second Chamber on June 9, 1910. In the exposition of the motives for its preparation reference is made to the desire expressed by the International Committee of Weights and Measures in its session of 1905, and to the decision of the Fourth General Conference. This law was promulgated Apr. 7, 1911.

Italy.—Parliament has already legislated, in principle, the new international carat (July 7, 1910); a Royal Decree will fix the date on which it shall come into use, after consultation with the National Commission of Weights and Measures.

Japan.—An ordinance of Nov. 11, 1909, specifies that "when the weights of precious stones are expressed in carats, the word 'carat' should designate the mass of 200 mg."

Mexico.—The government, considering that the designation "metric carat" merely constitutes an exception to the fundamental law, does not see any objection to tolerate the authorization of its use; it considers that this permission should be of a temporary character.

Norway.—The law authorizing the new carat bears date of May 27, 1910; the decree putting it in force was promulgated June 17 of the same year. The text of the law is as follows:

"The name 'metric carat' designates a special metric unity of mass, amounting to 200 mg., exclusively destined for the estimation of the price of diamonds, pearls, and other precious stones, and for their sale or purchase.

"The decimal multiples and subdivisions of the metric carat shall be authorized in so far as they may be necessary.

"The word 'carat' shall be in the future exclusively reserved for the designation of the mass above defined."

The decree establishes the series (similar to the metric series) of the multiple and subdivided weights of the carat. It also specifies that the carat-weights shall have the form of an equilateral triangle, one side of which shall be turned up.

Portugal.—The "metric carat" (*quilate metrico*) is included in the table annexed to the decree of Apr. 19, 1911.

Roumania.—A Royal Decree of Mar. 3, 1910, prescribes, from Jan. 1, 1911, the use of the new international carat: the verification of the

carat-weights is to be effected in conformity with the general rules comprised in the law concerning weights and measures.

Russia.—The reform of the carat is comprised in the general law in course of revision.

Servia.—The same conditions obtain here as in Russia.

Sweden.—The law establishing the new carat was promulgated June 10,1910; the obligation to observe it was fixed for Jan. 1, 1911.

Switzerland.—The carat of 200 mg. is comprised in the law on weights and measures promulgated June 24, 1909.

As may be seen, the new international carat 200 mg., adopted or in course of adoption in 17 countries, is prescribed by laws having slightly different texts, according to the sense in which the reform is viewed; in general, the prohibition implicitly contained in the law on weights and measures touching the use of any non-metric unity is expressly affirmed as regards the carat in common use, but the employment of the word "carat" to designate a mass of 2 decigrams is admitted as a toleration necessitated by the state of things, and justified by the special conditions of the commerce in precious stones.

In those countries in which no legislation has fixed the value of the carat, but where the metric system is in use, the toleration which has been enjoyed by the ill-defined unity by which the weight of precious stones has been computed, should *a fortiori* be applied to a unity strictly determined by its simple relation to the gram. We may therefore say that the reform is in reality more general than is indicated by the legal status of the carat.[1]

As a preliminary to the presentment of the law legalizing the use of the new carat in Holland, the measure was submitted by the Minister of Agriculture, Industry, and Commerce to the Amsterdamsche Juwelier's Vereinigung and to the Diamond Exchange of Amsterdam; these bodies concurred in advocating the change.

In conformity with a resolution passed by the Fédération Internationale des Bourses du Commerce de Diamants, Perles et Pierres Précieuses of Antwerp, at the convention of 1912, Adolph Adler presented to the Minister of Industry and to Senator Braun petitions for the legalization of the new carat, and received from the latter the assurance that he would urge the passage of a law to that effect in the Belgian Chamber of Deputies.

Not long since some fifty jewelers met in the rooms of the National Jewelers' Board of Trade, in New York, to consider the advisability of adopting the new standard. Prior to the meeting, M. D. Rothschild,

[1] Comité International des Poids et Mesures; *Procès-Verbaux des Séances*, Paris, 1911; 2d. ser., Vol. VI, Session of 1911, pp. 202–205.

who was elected Chairman, had sent out 4000 postal cards to leading jewelers in the United States, requesting their opinion on the subject of the introduction of a new international carat of 200 mg. Only about 360 replies were received; however, there was some consolation in the fact that but nine of these were negative.

Now that the new carat is likely to be soon in universal use, it would be well to consider whether jewelers should not substitute the use of the gram for that of the pennyweight. The grain is equivalent to about 64.8 mg. (more exactly 64.798918), and the pennyweight equals 1.555 g., the troy ounce being 31.1 g., and the troy pound 373.24 g. There can be little doubt that when the great convenience in computation resulting from the adoption of the new international carat of 200 mg. shall have been fully realized, the advantage of using the gram instead of the pennyweight will become clearly apparent, as in this way the troublesome multiplications by 24, 20, and 12 will be done away with. As five of the new international carats make exactly 1 g., all calculations regarding the weights of diamonds, pearls, and precious stones will then be in accordance with the metric system.

An important step in the direction of the official recognition of the new carat was the sending of a communication by Secretary Nagel, of the Department of Commerce and Labor, to the Secretary of the Treasury, recommending its adoption as the standard weight in computing the value of precious stones imported into the United States. The draft of this letter was prepared by Director S. W. Stratton, of the Bureau of Standards, Oct. 29, 1912. After drawing attention to the adoption of the new carat by so many European countries, the following excellent reasons are adduced for favorable action in the matter by the Treasury Department:

"The carat is not the most important element in estimating the value of precious stones, particularly of the diamond, but it is nevertheless important that its value be fixed. The change from the carat now used by the Treasury Department to the one proposed would probably be of no significance in so far as the amount of duty on precious stones collected by the Department is concerned, but it would be very important in its effect upon the unification of standards. I therefore have the honor to suggest that the Department adopt and use the international carat of 200 mg. and thus set an example which I feel sure will be followed by the jewelry trade in the United States."

Official steps have been taken by our State Department, at the suggestion of the Treasury Department, tending to secure common action by the governments of Great Britain, Holland, and Belgium with our own in the employment of the new international carat of 200 mg. to

determine the weight of all precious stones exported or imported into these countries, and the favorable action of the Treasury Department now realized was foreshadowed by S. W. Stratton, Director of the Bureau of Standards in Washington, D. C., in a letter of Jan. 28, 1913.

A number of representative dealers in precious stones met in London, on Feb. 7 of this year, under the auspices of the London Wholesale Jewelers and Allied Trades Association, Ltd., to consider the question of the new carat-weight. One of the speakers informed the meeting that the Board of Trade had been approached on the subject, and it appeared that its members thought favorably of the chances of the adoption of the new system in England after a little more propaganda work had been done there. The Board of Trade does not at present exercise any official control over the diamond weights in use, but a legalization of the new carat would result in the proper testing and stamping of the new series of weights.

A strong point made in favor of the adoption of the metric carat in England is that, according to the English Weights and Measures Act of 1878, the old carat is an illegal weight, this act expressly stipulating that gold, silver, and precious stones should only be sold by the ounce troy, or decimal part thereof. Hence it has been held that, strictly speaking, a contract to buy or sell so many carats' weight of diamonds would be an illegal contract and not enforceable. The new metric carat, on the other hand, would be fully covered by the Weights and Measures (Metric System) Act of 1897, and would therefore constitute a perfectly legal unit of mass.[1]

The carat-weight equaled essentially the Roman *siliqua*, 1/1728 of a Roman pound, 2.91 gr. troy, or 188.5 mg. It is interesting to note that at the present time this is the weight of the Bologna carat. The name is derived from the Greek *keration*, "little horn," and refers to the shape of the seed pods of *Ceratonia siliqua*, the carob-tree (St. John's Bread), the seeds of this tree having been used to weigh the precious material because their weight is fairly constant. The word carat has come to us through the Arabic *qîrât*, which became in Old Portuguese *quirate*, appearing in modern Portuguese and Spanish as *quilate*. A fourteenth century instance of the use of this word, under the form *garat*, to denote a pearl-weight is given in the *Nuremberg Chronicle*.[2]

The relation of the carat to the *siliqua* does not appear to have been constant, for Isidore of Seville, writing in the seventh century A. D., states that in his time a *cerates* equaled one and a half *siliqua*.[3]

[1] See W. J. Lewis Abbott and Leonard J. Spencer, in "The Watchmaker, Jeweler, Silversmith and Optician," pp. 1447, 1449, 1451 (Dec. 2, 1912).
[2] Grimm's "Deutsches Worterbuch," Vol. V, p. 73, art. Karat (Leipzig, 1873).
[3] Du Cange, "Glossarium mediæ et infimæ Latinitatis," Vol. II, p. 286; s. v. Cerates (Parisiis, 1842).

The weight of the seeds of *Ceratonia siliqua*, as averaged from 50 specimens, has been given as 197 mg. (3.04 gr.); the orange-red reniform seeds of *Erythrina corallodendron* had the same weight, while the lenticular seeds of *Adenanthara pavonina* gave a much higher average, namely 274 mg.[1]

The variations in the weight of the old carat are shown by the statement of Jeffries in 1751 that in his time there were *about* 150 carats in the ounce troy.[2] This would have given (if exactly 150) a carat value of 3.2 gr. or 207.357 mg.; later, John Mawe (in 1823) reckons 151.25 carats to the ounce, making a carat of 3.174 gr. The present English carat, having a value of 3.1683 gr., was already given by P. Kelly in 1831,[3] although it was not officially accepted by the English Board of Trade until 1888.

The following table of carat-weights heretofore in use in the various countries will give the general reader some idea of the chaotic conditions with which gem-dealers have been forced to contend:

DIAMOND CARATS.[4]

	Milligrams.	Grains Troy.
Turin	213.5	3.29480
Persia	209.5	2.23307
Venice	207.1	3.19603
Austro-Hungary	206.1	3.18060
France (old)	205.9	3.17752
France (later)	205.5	3.17135
France (modern)	205.0	3.16363
Portugual	205.8	3.17597
Frankfort and Hamburg	205.8	3.17597
Germany	205.5	3.17135
East Indies	205.5	3.17135
England and British India	205.3	3.16826
Belgium (Antwerp)	205.3	3.16826
Russia	205.1	3.16517
Holland	205.1	3.16517
Turkey	200.5	3.09418
Spain	199.9	3.08492
Java and Borneo	196.9	3.03862
Florence	196.5	3.03245
Arabia	194.4	3.00004
Brasil	192.2	2.96610
Egypt	191.7	2.95838
Bologna	188.6	2.91054
International carat of the year 1877	205.0	3.16363
New international carat	200.0	3.08647

We must note in this table the very wide discrepancy between the heaviest carat-weight, that of Turin, equivalent to 3.2948 gr. troy (213.5 mg.), and the lightest, that of Bologna, representing but 2.91054

[1] According to Leonard J. Spencer, a higher average weight for the seeds of *Ceratonia siliqua* has been given, namely, 205.2 mg. or 3.1667 gr., almost exactly that of the English carat; see G. F. Herbert Smith, "Gem Stones," p. 84 (London, 1912). The average of 3.04 gr. approaches very closely to the Florentine carat, 3.03245 gr.; this was probably the carat-weight used by Tavernier.

[2] David Jeffries, "A Treatis on Diamonds and Pearls," pp. 2, 3 (London, 1751).

[3] Patrick Kelly, "Universal Cambist" (London, 1831), Vol. I, p. 220, where he writes: "The Ounce troy weighs 151 1/2 Diamond carats, the carat is therefore 3 1/6 gr. troy or 205 1/4 French Milligrammes."

[4] "The Book of the Pearl," by George F. Kunz and Charles H. Stevenson, p. 323 (New York, 1908).

gr. troy (188.6 mg.). Hence the Turin carat is a little more than 13 per cent. heavier than that of Bologna, an enormous difference when we have to deal with such costly commodities as precious stones.

The impossibility of carrying on a diamond business systematically with such an appalling variation in the weight of the diamond carat, and with no possible means of an effective check to determine the accuracy of the weights employed, must be clear to all. It is a fact that a great number of jewelers use a set of weights for as many as 20 years, and in the meantime these weights will either wear off, or, if they are handled and lifted with the fingers, as is often the case, they may become heavier.

A government official informed me at Washington that a number of sets of weights used in various establishments were tried, and, to the astonishment of every one concerned, a wide variation was found in them, due to their long use and to the varying standards of different nationalities. If we had a definite standard, a special set could be kept for testing and checking up, once a month, or every 3 months, the weights in use, discarding those that varied. Thus, there would be much greater accuracy in the books of an establishment if the new international carat of 200 mg. were used.

A useful publication in French to aid in making computations from one carat system to the other is that issued in 1912 by G. Ymonnet, and entitled *Barême des relations entre le carat métrique à* 200 *mm. et le carat ancien à* 205 *mm.* The exact ratio of the English Board of Trade carat, that officially recognized in Great Britain, to the new international carat, is as 1 to 1.0265.

The fact that the general adoption of the new international carat owes so much to the activities of the Director of the International Committee of Weights and Measures, the directing body of the International Bureau of Weights and Measures, suggests a few words in regard to this Committee. Organized under a treaty signed in Paris, in 1875, by 20 of the leading nations of the world, it was intrusted with the important task of supplying the various interested nations with standard platinum-iridium meters and kilograms, conforming strictly to their prototypes, the original meter and kilogram recognized as standards by the French government in 1799. When, in 1889, this task had been successfully accomplished, one of the new meters and one of the kilograms were chosen as international prototypes, and each of the different countries represented in the Bureau received an allotment of one or more of these standards of length and mass. Two meters and two kilograms fell to the lot of the United States. These are now kept at the Bureau of Standards at Washington and constitute the fundamental metric standards of length and mass for our land. The international prototypes in Paris are care-

fully preserved in a specially constructed underground vault, and are only accessible to the International Committee. To insure the maintenance of strict conformity between the different metric standards, the Committee contemplates the introduction of comparisons between them at such times as may seem expedient. The International Bureau has the joint support of the following countries: the United States, Great Britain, Germany, Russia, France, Austria-Hungary, Belgium, Argentine Confederation, Spain, Italy, Mexico, Peru, Portugal, Roumania, Servia, Sweden, Norway, Switzerland, Venezuela, Japan, and Denmark.[1]

There is, in the rooms of the Chambre Syndicale in Paris, a standard balance, which is verified once every month by the Maison Exupère. Access can be had to this balance by any member at any time, and this aids materially in securing standard weights of absolute accuracy. There are two great sources of error: one is the accretion of dust and perspiration; the other is the wearing away of the weights by friction on the pan of the balance, in the weight box, and by the tweezers in lifting them up.

The writer had a set of the new international weights made in 1910. These new weights, which will be required as soon as the new international carat of 200 mg. shall be generally recognized and employed by American gem-dealers as the standard weight for precious stones, have already been made by a number of balance-makers. The price charged for a set of these weights, 18 in number, ranging from 100 carats to 1/100 carat, is $3.80; of course, a fuller set would cost a proportionately higher price. It has been stated that there is really no such weight as a "pearl grain;" yet while this is, strictly speaking, a fact, the so-called "pearl grain" being merely a quarter-carat, the term has so generally been used and is so well understood by all familiar with precious stones and pearls, that it may be said to be "consecrated by usage." In any case, however, the statement that, with the introduction of the new carat, pearls can be weighed with greater accuracy, is a perfectly just one, for the advantage of having a fractional weight as small as 1/25 of a "pearl grain," instead of being confined as at present to the larger fraction of 1/16 (1/64 carat), is clearly manifest.

The value of pearls is computed by squaring the number of "pearl grains" (quarter-carats) and multiplying the product by a figure determined upon as the base value of the grain. To ascertain the exact value of a pearl having a certain weight in metric carats, we should first multiply the figures by four, which will give us the number of "metric pearl grains," and then multiply this product by itself, the result being in turn multi-

[1] "The International Metric System of Weights and Measures," pp. 3, 4, Department of Commerce and Labor, Bureau of Standards, S. W. Stratton, Director (Washington, 1906).

plied by the figure representing the value in dollars of a "base-grain." For example, in the case of a pearl weighing 3.64 metric carats and having a base-grain value of $6, we proceed as follows:

$3.64 \times 4 = 14.56$ (number of "pearl grains").
$14.56 \times 14.56 = 211.9936$.
$211.9936 \times 6 = 1271.9616$ (value of pearl in dollars).

That is to say, such a pearl would be worth $1271.96. Several books have been published containing the squares and cubes, and square-roots and cube-roots, of a long series of numbers, and any one of them would prove useful in these operations.[1]

The astute diplomatist, Talleyrand, is credited with the basic idea of the metric system, namely, the acceptance of the length of a pendulum beating seconds on latitude 45°, as a standard unit of length. This proposition, made by him in 1790, was accepted by the French National Assembly and the sovereign, Louis XVI. The details of the system were worked out by the great French mathematicians Borda, Lagrange, Laplace, Condorcet, and Monge, who constituted a committee appointed by the French Academy of Sciences for this purpose.

Decimal notation, without which the metric system would have been an impossibility, is said to be of Hindu origin, although it reached Europe through the Arabs. Abu Ja'far Mohammed ben Musa, named Al-Khowârazmi from his birthplace, Khwârazm (Khiva), and who flourished in the ninth century A. D., is considered to be the originator, or introducer of decimal notation among the Arabs, and the introduction of the system into Europe has been traced to a translation of one of his works made in 1202 by Leonardo of Pisa.

The nine numerals with the zero were introduced among the Arabs about 773 A. D. and are by some believed to have been brought by an Indian ambassador to Bagdad at that time. Of their use in India at an earlier period we have monumental evidence in rock inscriptions, and, while the earliest date expressed in these Hindu numerals is 738 A. D., there is sufficient proof of their employment as early as the sixth century.

Introduced to Europeans at the beginning of the thirteenth century, the so-called Arabic numerals very gradually came into general use. For example, in the calculation of the tides in London, in the thirteenth century. A work of Petrarch, printed in Cologne in 1471, has the pages numbered in this way.

[1] "Barlow's "Tables of Squares, Cubes, Square-roots, Cube-roots, Reciprocals, of all Integral Numbers up to 10,000." (London, 1882.)
Dr. A. L. Crelle's "Rechentafeln," (Berlin, 1889).
W. Palin Elberton, "Tables of Powers of Natural Numbers in Biometrika," Vols. II. and IV., pp. 474—480 (Cambridge, Mass., 1913).

The earliest example of the decimal point is said to be found in the Arithmetic of Frances Pellos, written in the dialect of Nice, and published at Turin in 1492.[1]

The first appearance of the symbols + and − in a printed book is in an arithmetic of Johann Widmann printed in Leipzig in 1489,[2] and the sign denoting equality, =, is first found in print in Robert Recorde's (1510?–1558) "The Whetstone of Witte,"[3] or the second part of "Arithmetike," London, 1557. He is believed to have adapted it from a similar sign used in medieval manuscripts as an abbreviation of the Latin *est*, "is." Rahn is credited with the first use of the symbol of division, ÷, and Thomas Harriot is said to have been the first to print the signs > and <, denoting respectively excess and deficit, in his "*Artis analyticae praxis*," London, 1631.

A simple method of making a rough mental calculation of certain metric weights and measures into equivalents of the English standards is given by Albert A. Cary.[4] This may be in many cases accomplished by merely adding 10 per cent. to the figures expressing the metric quantity. For instance, 1 meter equals 1.094 yd. nearly; the error in turning meters into yards in this way amounts to a trifle less than 6/1000 yd. in each meter. Thus 67 meters would equal 67+6.7 yd., or 73.7 yd., or, multiplying this by three, 221.1 ft.; the more exact equivalent being 73.27 and 219.82, respectively. With the kilogram the metric figures must be doubled and then 10 per cent. added to the product to get an equivalent number of avoirdupois pounds, as the kilogram equals 2.204 lb. avoirdupois. Hence 76 kg. can be thus roughly turned into pounds: $76 \times 2 = 152 + 15.2 =$ 167.2 lb., the exact equivalent being 167.504 lb., a comparatively slight error when only an approximation is sought. An addition of 5 per cent. to the figures expressing a given number of liters would also offer a fairly close approximation to the number of quarts. If we take, for example, 64 liters, we have: 64+3.2=67.2; here the exact equivalent is 67.629 qts.

In a communication to the Société Française de Physique in Paris, Edouard Guillaume calls attention to a slight difference which exists between the liter and the kilogram or cubic decimeter of water. Accurate modern measurements have shown that the difference amounts to 27/1,000,000 or a little over 1/40,000. This very slight, but still appreci-

[1] "Sen seque de la art de arithmeticha, et semblatement de ieumetrica dich ho nommatus copendio de lo abaco (compilada es ea opera per Fr. Pellols), Impresso in Thaurino lo presente copendio de abaco per meistro Nicolo benedeti he meistro Jacobino luigo de sancto germano—Nel anno 1492 ad Di 28 de Septembrio.

[2] Wildman, J., "Behede und hubsche Rechenung allen Kauffmanshafft," Leipsick, Chr. Kacheloffen, 1489. 8°, 236 pp.

[3] The title "Whetstone of Witte," is the translation of *cos ingenii*, a punning allusion to coss (thing), early used to signify our algebraic *x*, or unknown quantity.

[4] Simple Approximate Metric Conversions, *Power*, Vol. XXXVII, No. 7 pp. 217 to 219 (Feb. 18, 1913).

able, error is due to the fact that the liter represents the volume of the kilogram of water at its maximum of density under atmospheric pressure.

The metric system was legalized in the United States by the act of July 28, 1866, and although its progress toward popular and general recognition and employment has been unfortunately slow, at intervals since that date certain special official enactments have prescribed its use in particular cases, as in the postal service, where the post offices exchanging mails with foreign countries are provided with balances denominated in metric grams, under the terms of Section 3880 of the Revised Statutes. A much more important case, however, because it concerns an exclusively national use of the metric system, was the enactment that the weight of the half-dollar, the quarter-dollar, and the dime should be computed in grams, the half-dollar to weigh 12.5 grm. and the quarter-dollar and dime respectively one-half and one-fifth of this weight. In 1894 a further step was taken by the enactment that the international units based on the metric system should be "the legal units of electrical measure in the United States."

Already, by an order approved Apr. 15, 1878, the Secretary of the Navy had directed that the metric system should be used in the Medical Department of the Navy, and later, Apr. 13, 1894, it was ordained that all requisitions and accounting for medical supplies in the War Department should be made in conformity with the metric standard. The scope of these regulations was broadened by Executive orders of Nov. 21, 1902, providing that "for all official, medical, and pharmacal purposes, officers shall make use of the metric system of weights and measures."

In our colonies, Porto Rico and the Philippines, the metric system had been in use long before the date of our occupation, and its continued use, for Porto Rico, was made obligatory by a proclamation of the military governor, dated Mar. 18, 1899, while in the case of the Philippine Islands the continuance of its employment was legalized under Sections 3569 and 3570 of the Revised Statutes.

It is not only in the form of the new international carat that the metric system has found application in determining the dimensions of precious stones. Certain classes of these stones are distinguished and sorted by passing them through sieves graded according to the diameters of their apertures expressed in millimeters. The apparatus used consists of a brass ring grooved on the inner side so that there may be set within it a series of sieves. A sieve of a certain grade having been duly adjusted, the stones to be measured are placed upon it, and shaken to and fro until all smaller than the apertures of this particular sieve have passed through it. These stones are then gathered up and placed upon a sieve with smaller apertures, and those which do not pass through this latter sieve are

classed by its serial number. Pearls are also sometimes classified in the same way.

Here, however, as in the case of the carat, a fixed standard has been lacking, there being Paris stone-sieves with a difference of about 1/5 mm., Paris and Idar "pearl-sieves" with a progressive difference amounting to from 1/25 to 1/5 mm. and Bohemian garnet-sieves with approximately the same progressive difference as the Paris sieves. But this theoretical uniformity does not exist practically, for the sieves are not standardized, and those used by one dealer may and do usually differ from those used by another. Moreover, the ratio of difference between sieve and sieve is not constant. In the case of some numbers, or grades, it amounts to 1/3 mm., while in the case of others it is but 0.1 mm., so that a great quantity of stones will be placed in certain grades and very few in certain other grades. To obviate all these difficulties an international series of sieves has been proposed. The No. 1 sieve is to have apertures of 0.1 mm., each succeeding number to have apertures 0.1 mm. greater in diameter, so that in the case of the No. 10 sieve this would measure 1 mm.; No. 20, 2 mm., and so on. By this means the number of the sieve would immediately and invariably denote the diameter of the holes; in the case of No. 17, for instance, the diameter would be 1.7 mm.; for No. 36, 3.6 mm. As another improvement, it is suggested that the sieves be made as thin as possible, and that thin steel plates be substituted for brass as a material.

COUNTRIES WHICH HAVE DEFINITELY ACCEPTED AND LEGALIZED THE METRIC CARAT.

Spain	1908
Japan	1909
Switzerland	1909
Italy	1910
Bulgaria	1910
Denmark	1910
Norway	1910
Holland, law promulgated Apr. 7	1911
Portugal	1911
Roumania	1911
Sweden	1911
France, adopted June 22, 1909; legalized Jan. 1	1912
Germany	1912
Belgium	1913
England	1913

The following resolution was adopted at the Eighth Annual Conference on the Weights and Measures of the United States, held at the Bureau of Standards, May 14 to 17, 1913:

"*Resolved*, that this Conference is in favor of the metric carat-weight of two hundred (200) milligrams being adopted as the standard of weight for precious stones."

It has been suggested that as every state having a special department of weights and measures should be properly equipped for the task of

testing the accuracy of weights and balances used for precious stones, provision should be made for officially verifying such weights and balances, the owners merely needing to defray the costs of transportation, which would be inconsiderable.[1]

In a letter sent in the latter part of May, 1913, to G. E. M. Johnson, Secretary of the Decimal Association of London, some important information is conveyed by P. A. MacMahon, deputy warden of the standards of the English Board of Trade, promising the general adoption of the new metric carat in England in the near future. He writes:[2]

"In reply to your letter of the 21st of May respecting the adoption of the metric carat in the sale of diamonds and other precious stones, I have to acquaint you that the Department has now decided to take steps to make the metric carat and its necessary multiples and submultiples standard weights in the United Kingdom, and that an Order in Council giving effect to this decision will probably be issued this year."

On July 1, 1913, the provision went into effect in Belgium making the metric carat the standard of weight for precious stones in that country, and it is confidently expected that in Holland, where the extensive diamond interests are so nearly allied to those of Belgium, a similar provision will be very shortly enacted. It is thus probable that by 1914 the six countries chiefly interested in the diamond trade, the United States, Great Britain, Germany, France, Holland, and Belgium, will all be freed from the use of the antiquated and complicated carat-weights of the past.

In an interesting and instructive address delivered by Dr. Louis A. Fischer, of the United States Bureau of Standards, before the Retail Jewelers' Association of the District of Columbia, the speaker took occasion to assure his hearers that the jewelers of this country could count upon the assistance and support of the Bureau of Standards if they followed the example set by their European confrères.[3]

For jewelers and gem-dealers doing business in New York, a fact of considerable interest is that the Mayor's Bureau of Weights and Measures is ready, after July 1, 1913, to place its services at the disposal of the general public in correctly determining the weights of precious stones according to the carat of 200 mg. Commissioner John L. Walsh states that the mechanical department of the Bureau, at 224 West 49th Street, will then be supplied with facilities for weighing gems from 1/100 carat to 500 carats, in accordance with the new standard. While no other city department is as yet able to furnish this service, the New York State

[1] G. A. Dasney, The Application of the Weights and Measures Question to the Jewelry Trade, *Jewelers' Circular Weekly* (Apr. 24, 1912).
[2] *Jewelers' Circular Weekly* (June 11, 1913).
[3] In a personal letter, Mar., 1913.

Bureau of Weights and Measures, at Albany, and the National Bureau of Standards, at Washington, D. C., can verify sets of the new weights by means of the standard weights deposited there.

In conclusion, it is a pleasure to chronicle the definite official acceptance of the new carat by the United States Treasury Department. On June 17 instructions were issued by the Department to collectors of customs prescribing the metric carat of 200 mg. as the standard unit of weight for imported diamonds and other precious stones, and for pearls; these instructions to take effect July 1, 1913.

The use of the new carat-weights has received the approval of the National Jewelers' Board of Trade, A. Henius, President; the National Jobbers' Association, and the American National Jewelers' Association; and each of these bodies has passed a resolution commending the metric carat and recommending that members should employ it as a standard weight after July 1, 1913.

The resolutions of the National Jewelers' Board of Trade, passed at a meeting of the Board of Directors, held Nov. 14, 1912, read as follows:

After discussion it was moved, seconded, and carried:

"That the National Jewelers' Board of Trade most heartily endorse the movement of the Committee that was formed for the purpose of the adoption of the decimal metric carat, and recommend to its full membership the adoption thereof, in accordance with the Resolution passed at the meeting held October 29, and that the President be authorized to appoint ten members of this Board to coöperate with the Committee to be appointed by Mr. Rothschild, and that the Secretary be instructed to notify every member of the Board of the action taken here to-day; that the President or the Secretary communicate the action of the Board to the proper officials of the National Retail Jewelers' Association and National Jobbers' Association, requesting them also to use their influence for the decimal metric carat system."

In addition to the jewelers already noted, no one has been more indefatigable in the introduction of the international carat of 200 mg. than Mons. Ch. Ed. Guillaume, Director of the Bureau Internationale des Poids et Mesures of Sèvres; the late Mons. Leon Rheims, President of the Chambre Syndicale des Négociants en Diamants, Perles, Pierre Précieuses et des Lapidaires de Paris; and in this country, Dr. S. W. Stratton, Director of the Bureau of Standards, Department of Commerce and Labor, and Hon. James F. Curtis, Assistant Secretary of the United States Treasury.

INTERNATIONAL CARAT

(Appendix)

On receipt of a communication from the Secretary of State for the Interior to the effect that by the terms of the law regarding the use of the metric system, the employment of a metric carat was permissible without special legislation, the German Federation of Jewelers and Goldsmiths adopted in March, 1911, a resolution for its introduction. The only slight obstacle encountered at the outset was that the Normal Standardization Commission found the carat-weights first prepared for commercial use not to be susceptible of standardization; it was therefore necessary to modify the original forms. An ordinance of April 1, 1912, generalizes the use of the carat.[1]

The adoption of the metric carat will form part of the new regulations on the metric system to be introduced shortly in the Argentine Republic, this new legislation having been delayed to await the results arrived at in France, where the Minister of Commerce is preparing a systematization of the French law.[2]

In Austria a law has been introduced in the Chambers providing for the adoption of the new carat.[3]

The law determining the value of the new carat was promulgated in Belgium, March 10, 1913; it consists of the following single article:[4] "In transactions relating to diamonds, pearls and precious stones, the denomination metric carat, in derogation of the articles 1 and 3 of the law of October 1, 1855, may be given to a weight of 200 mg. The use of the name 'carat' to designate any other weight is forbidden."

The new law in Bulgaria regulating the metric system, published March 27, April 10, 1910, includes in its sixth article the adoption of the metric carat.[5]

The Italian law adopting the carat, promulgated January 7, 1910, left the date of its definite establishment to a Royal Decree; this was issued August 9, 1911, and sets the date of January 1, 1912, for the official introduction of the new carat in commercial transactions, it enumerates a series of carat-weights from 500 mg. to 2 mg., or from 1/2

[1] "Les recents progrès du système métrique; rapport présenté à la Cinquième Conférence Générale des Poids et Mesures, en October 1913, par Ch.-Ed. Guillaume," Paris 1913, p. 87.
[2] *Op. cit.*, pp. 78, 87.
[3] *Op. cit.*, p. 87.
[4] *Op. cit.*, p. 88.
[5] *Op. cit.*, pp. 61, 89.

carat to 1/100 carat; these weights are to be stamped with the letters *C. M.*, as in France.[1]

In France there was, for a time, a disposition on the part of some dealers in precious stones to favor a binary division of the new carat similar to that which had prevailed in the divisions of the old carat, but the French government realized that in order to maintain the integrity of the metric system the fractions of the new carat should be decimalized. Each weight bears incised in legible characters the number and fractions of grams on its lower face, while on the upper face is marked in a like way the number and fractions of the metric carat, followed by the abbreviation *C. M.* While the decrees of July 7 and December 13, 1910, prescribe that the form of these weights shall be that of a truncated quadrangular pyramid, or of a cylinder surmounted by a button, the weights of less than 1 gr. are metal plates cut square.[2]

The Bureau of Standards issued on November 1, 1913, a special circular (No. 43) devoted to the metric carat.[3] After recording the recognition of this carat by the Bureau, from July 1, 1913, as the unit of weight for diamonds and other precious stones, as well as the use of it from the same date by the United States Treasury Department in the custom's service, the circular gives a number of tables showing the equivalents of fractions of the old carat (2.053 mg.) in decimals of the metric carat of 200 mg., and *vice versa*. A section is also devoted to the details of weighing and weights, offering some valuable suggestions in relation to the treatment of balance and scales and the proper conformation and handling of the new carat weights. The importance of having these made of a single, homogeneous piece of metal, without attachable or detachable knobs or screwed-on parts of any sort, is insisted on. The adaptability of brass for weights over 5 carats is admitted, but their protection from oxidation by plating or lacquer is advised; the smaller weights can be of platinum, and the smallest of aluminium. All should conform to the standards of the Bureau, within the margin of tolerances running from ±0.05 mg. for 0.01 carat to ±70 mg. for 2500 carats.

A more decided step than the mere recognition and even the official use of the new metric carat has been very recently taken by the Massachusetts legislature. This act, Chapter 183 of the Acts and Resolves of 1914, consists of an amendment to the first section of Chapter 63 of the Revised Laws. This section permits the use of the metric system in general and authorizes the use of the metric weights and measures "received from the United States and now in the treasury of the commonwealth," for-

[1] *Op. cit.*, pp. 90, 91.
[2] *Op. cit.*, p. 89.
[3] Department of Commerce. Circular No. 43 of the Bureau of Standards, S. W. Stratton, Director. "The Metric Carat," 1st ed. issued November 1, 1913, Washington, Government Printing Office, 1913, 12 p. 8°.

bidding their removal except for absolutely necessary repair. The new amendment, however, introduces the following emphatic provision: "Provided, however, that the carat weight of 200 mg., and its multiples and subdivisions, shall be the sole legal standard for the buying and selling of diamonds and precious stones."

This compulsory use of the metric carat is to be enforced from September, the bill or act which was approved on March 16, 1914, containing the provision that it shall become operative 6 months after the date of its passage.

A final blow to the cumbersome system of registering the weights of diamonds and precious stones in sixty-fourths of a carat, was dealt in Belgium by a Royal Decree of October 31, 1913, which made it compulsory for all computations of diamond weights to be expressed in decimals of the new metric carat.[1]

Reichstagsgesetzblatt.—Decree regarding Weights and Measures of May 30, 1908.

1. The fundamental standards of Measures and Weight are the Meter and the Kilogram.

Both President Lincoln and Secretary Seward were greatly interested in the question of the establishment of an international uniform standard of weights and measures, so much so, that in the very darkest hours of our dreadful Civil War Secretary Seward addressed a letter, dated January 8, 1864, and written on his own behalf as well as on that of the President, warmly accepting the proffered aid of the National Academy of Sciences in this direction, and expressing his readiness to thankfully receive at any time suggestions bearing on the subject, or committees appointed for its discussion. Already, in 1863, the Academy had appointed a committee on Weights, Measures and Coinage, at the request of the Treasury Department. In 1886, a committee on Metric Standards for the States, and in 1873 one on an International Bureau of Weights and Measures were appointed.[2]

The definite legalization of the Metric Carat in England was brought about by an Order in Council of October 14, 1913. After citing Section 8 of "The Weights and Measures Act, 1878," which provides that the Board of Trade shall, from time to time, as may seem advisable, construct new denominations of standards, multiples or aliquot parts of the already recognized weights or measures, and noting that "The Weights and Measures (Metric System) Act, 1897" includes among these standards the iridio-platinum kilogram numbered 18, the Order proceeds:

[1] Consul General Henry W. Diederich, of Antwerp, in *Daily Consular and Trade Reports*, March 28, 1914, p. 1171.

[2] Dr. George Ellery Hale, "National Academies and the Progress of Research," *Science, N. S.*, XXXIX, No. 997, p. 192.

"Now, therefore, His Majesty, by virtue of the power vested in him by the said Acts, by and with the advice of the Privy Council is pleased to approve of the new denominations of standard weights specified in the schedule hereto, and doth direct that the same, on and after the 1st day of April, 1914, shall be Board of Trade standards in like manner as they were mentioned in the Second Schedule of the Weights and Measures Act, 1878."[1]

Schedule.—Denominations of Standards of Metric Carat Weights.

	Denominations.			Weights in Grams.
500.0	Metric Carats	(500.0	C. M.)	100.0
200.0	Metric Carats	(200.0	C. M.)	40.0
100.0	Metric Carats	(100.0	C. M.)	20.0
50.0	Metric Carats	(50.0	C. M.)	10.0
20.0	Metric Carats	(20.0	C. M.)	4.0
10.0	Metric Carats	(10.0	C. M.)	2.0
5.0	Metric Carats	(5.0	C. M.)	1.0
2.0	Metric Carats	(2.0	C. M.)	0.4
1.0	Metric Carats	(1.0	C. M.)	0.2
0.5	Metric Carats	(0.5	C. M.)	0.1
0.2	Metric Carats	(0.2	C. M.)	0.04
0.1	Metric Carats	(0.1	C. M.)	0.02
0.05	Metric Carats	(0.05	C. M.)	0.01
0.02	Metric Carats	(0.02	C. M.)	0.004
0.01	Metric Carats	(0.01	C. M.)	0.002
0.005	Metric Carats	(0.005	C. M.)	0.001

While as far as it goes this is a recognition of the practical value of the decimal system, its use ceases with the ounce weight, and we do not escape the troublesome computations necessitated by the division of the pound into 12 or 16 oz. Were this not the case there might have been some advantage in accepting 0.01 of an ounce as an exact equivalent of 1.5 carat, which would have raised the carat weight exactly 1 per cent., to 3.2 gr., from the former English weight of 3.1683+ gr.[2] In the adoption of the metric carat the weight has been *reduced* to 3.0864 gr. However, over and above the fact that the use of decimals does not extend beyond the ounce, the metric carat possesses the important advantage of bringing about absolute uniformity in the weighing of precious stones among all the nations, a result only attainable by conforming the carat-weight to the metric system.

[1] From, *Horological Journal*, Jan. 1914, pp. 68, 69.

[2] J. W. Abbot, "A Manual of the Decimal System . . . also A Ready Reckoner," London (1876) v + 85 p., 12°.

DATA OF THE WORLD'S PRINCIPAL MINES.

By S. F. Shaw.[1]

Compiled from Annual Reports of the Respective Companies.

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Cost per Ton.	Ore Reserves Tons.
Abosso Gold	W. Af.	'11–'12	89,322	£16,683	.....	$8.08	229,128
Ahmeek	U. S.	1912	652,260	1,465,397	1,100,000	1.97	.....
Alaska-Mex	Alas.	1912	233,299	319,353	225,000	2.05	1,040,631
Alaska-Gold	Alas.	1912	74,930	.....	.....	0.78	.....
Alaska-Treadwell	Alas.	1912	892,198	548,651	650,000	1.92	5,977,958
Alaska-United	Alas.	1912	450,793	323,105	324,360	2.16	2,875,794
Allouez	U. S.	1912	330,618	.....	.....	.....	.....
Amalgamated Zinc	Aus.	½–1912	278,234	£84,757	£62,500	.....	.....
Amparo	Mex.	1912	92,365	389,225	240,000	4.60	559,099
Anaconda	U. S.	1912	4,576,289	.....	9,804,375	.....	.....
Ashanti Goldfields	W. Af.	'11–'12	153,554	£214,425	.....	.....	392,840
Assoc. Northern Blocks	Aus.	'11–'12	20,476	.....	.....	11.85	.....
Aurora West	Tran.	1912	162,597	£42,382	.....	4.78	467,064
Balaghat Gold	India	1912	42,435	—£2,421	.....	7.88	24,725
Baltic	U. S.	1912	652,433	.....	700,000	2.26	.....
Batopilas	Mex.	1912	.....	162,404	.....	.....	.....
Bibiana	W. Af.	1912	80,154	—£13,731	.....	6.58	.....
Blackwater	N. Z.	1912	11,538	£7,761	.....	10.70	.....
Boleo	Mex.	1912	364,850	1,750,000	.....	.....	.....
Brakpan	Tran.	1912	637,523	£444,117	£300,000	4.53	2,457,000
Bantjis	Tran.	1912	286,553	£70,847	£56,509	5.97	840,800
British Broken Hill	Aus.	½–1912	101,390	£62,067	£60,000	.....	.....
		½–1912	103,710	£61,836	£46,374	.....	2,000,000
British Columbia Copper	Can.	1912	443,022	425,986	177,512	.....	.....
Broken Hill North	Aus.	½–1912	124,540	£91,651	£93,250	5.15	.....
		½–1912	125,738	£15,104	£160,000	5.70	2,186,000
Broken Hill Block 10	Aus.	½–1912	47,954	£36,049	£10,000	.....	283,500
Broken Hill Block 14	Aus.	½–1912	11,732	£11,603	.....	.....	.....
		½–1912	14,657	£20,923	£1,000	.....	.....
Broken Hill Proprietary	Aus.	½–1912	109,619	£186,883	£120,000	.....	.....
		½–1912	120,839	£164,903	£144,000	.....	2,000,000
Broken Hill South	Aus.	½–1912	165,532	.....	£120,000	4.77	.....
		½–1912	180,080	£222,022	£170,000	4.67	3,250,000
Buffalo	Can.	'11–'12	46,810	451,154	370,000	.....	.....
Bunker Hill & Sullivan	U. S.	1912	702,520	1,446,924	1,209,900	5.74	3,782,070
Calumet & Arizona	U. S.	1912	337,942	.....	2,534,500	10.15	.....
Calumet & Hecla	U. S.	1912	2,806,610	.....	4,200,000	2.37	.....
Camp Bird	U. S.	'11–'12	66,505	£287,326	1,023,030	8.79	.....
Cape Copper	S. Af.	'11–'12	77,995	£55,137	£50,375	.....	36,000
Carn Brea & Tincroft	Eng.	½–1912	45,444	£7,321	.....	5.71	.....
Caucasus Copper	Russ.	'11–'12	.....	£66,397	.....	.....	3,600,000
Centennial	U. S.	1912	106,517	.....	.....	2.20	.....
Centennial Eureka	U. S.	1912	117,957	.....	300,000	.....	.....
Champion	U. S.	1912	765,306	.....	1,200,000	2.00	.....
Champion Reef	India	1912	.....	.....	.....	7.75	.....
Chino	U. S.	1912	1,101,463	2,212,169	.....	1.93	54,970,640
Cindrella Con	Tran.	1912	211,578	£44,591	.....	6.14	573,000
City & Suburban	Tran.	1912	323,934	£253,939	£204,000	6.14	773,300
City Deep	Tran.	1912	479,630	£255,548	£156,250	6.05	2,123,650
Cons. Langlaagte	Tran.	1912	295,072	£99,446	.....	4.62	2,069,630
Con. Main Reef	Tran.	'11–'12	242,716	£94,134	£80,881	5.12*	610,680
Copper Queen	U. S.	1912	692,995	.....	.....	.....	.....
Crown Mines	Tran.	1912	1,920,700	£1,137,605	£1,034,116	4.71*	10,607,671
Crown Reserve	Can.	1912	.....	1,136,010	1,061,288	.....	.....
Daly Judge	U. S.	1912	62,606	.....	225,000	6.58	.....
Detroit Copper	U. S.	1912	519,722	.....	.....	.....	.....
Dome	Can.	'11–'12	101,812	.....	.....	4.95	.....
Durban-Roodepoort	Tran.	1912	165,920	£34,957	£31,250	4.26	600,000
Durban-Roodepoort Deep	Tran.	1912	293,975	£71,074	£44,000	6.09	965,300
East Butte	U. S.	1912	96,601	983,701	.....	.....	.....
El Paso	U. S.	1912	.....	238,757	122,500	.....	.....
East Rand Proprietary	Tran.	1912	1,849,290	£848,793	£611,474	5.81	6,013,300
Eldorado Banket	Rhod.	'11.'12	87,315	£92,972	£90,000	7.40	149,749
El Oro	Mex.	'11–'12	302,698	£182,149	£143,437	.....	301,934
Esperansa	Mex.	1912	124,888 tailing ore 85,838	.....	506,250	6.00	166,618
Esperansa Sulphur & Cop.	Spain	1912	97,566	£36,062	£17,500	.....	.....
Federal Mace	U. S.	1912	154,920	172,997	.....	7.53	.....

[1] From *Eng. Min. Jour.*, Jan. 17, 1914.

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Cost per Ton.	Ore Reserves Tons.
Federal Wardner	U. S.	1912	250,000	56,081	.....	$4.41	.....
Ferreira Deep	Tran.	'11–'12	558,920	£521,560	£402,500	5.59	.....
Franklin	U. S.	1912	.....	.....	.....	.....	.....
Gaika Gold	Rhod.	'11–'12	34,243	£13,921	£13,674	6.78	57,758
Geduld Proprietary	Tran.	1912	168,740	£49,338	.....	5.08	1,475,000
Geldenhuis Deep	Tran.	1912	628,210	£125,563	£87,862	6.35	1,904,700
Giant	Rhod.	'11–'12	13,209	£120,572	£98,720	3.65	.....
Ginsberg	Tran.	1912	167,922	£63,845	£68,250	5.46	.....
Glencairn	Tran.	1912	236,685	£34,022	£27,500	3.05	205,418
Giroux	U. S.	1912	141,287	.....	.....	.....	.....
Globe & Phoenix	Rhod.	1912	72,923	£299,814	£280,000	12.10	170,945
Glynn's Lydenberg	Tran.	'11–'12	37,325	.....	£42,500	6.18	69,200
Golden Horseshoe	Aus.	1912	280,868	49,000	.....	.....	714,141
Goldfield Con	U. S.	1912	415,786	4,886,400	5,694,637	6.72	300,000
Granby	Can.	'11–'12	721,719	—17,183	.....	.....	6,433,418
Great Cobar	N. S. W.	'11–'12	347,317	£34,356	.....	.....	2,738,547
Great Boulder Perseverance	Aus.	1912	234,636	£25,681	£33,986	5.08	498,260
Great Boulder Proprietary	Aus.	1912	193,451	£307,744	£262,500	.....	652,916
Great Fingall	Aus.	1912	67,177	.....	.....	.....	51,459
Greene Con	Mex.	1912	.....	2,280,709	1,400,000	.....	.....
Grenville	Eng.	½–1912	20,166	£13,794	£13,912	.....	.....
Hainalt	Aus.	'11–'12	63,542	—£2,901	.....	6.25	100,000
Hecla	U. S.	1912	138,588	335,612	300,000	5.23	.....
Hedley Gold	Can.	1912	70,455	385,880	360,000	5.14	413,000
Hercules	U. S.	1912	34,195	715,763	.....	4.26	.....
Hollinger	Can.	1912	45,195	391,808	270,000	11.99	644,540
Homestake	U. S.	1912	1,528,923	.....	1,310,400	2.96	.....
Horn Silver	U. S.	1912	9,030	8,606	.....	.....	.....
Hutti Gold Mines	Ind.	'11–'12	17,485	£4,510	£3,480	11.64	20,000
Inspiration	U. S.	.....	.....	.....	.....	.....	45,000,000
Iron Blossom	U. S.	1912	59,467	.....	370,000	.....	.....
Iron Silver	U. S.	1912	46,412	.....	200,000	.....	.....
Isle Royale	U. S.	1912	.....	430,045	.....	.....	.....
Ivanhoe	Aus.	1912	237,266	960,000	912,000	5.40	1,080,000
Jumbo Gold	Rhod.	'11–'12	38,210	—£27,459	.....	11.50	9,690
Jupiter	Tran.	1912	476,902	£63,632	£50,710	4.39	1,270,000
Kalgurli	Aus.	'11–'12	123,800	£95,768	£96,000	4.98	250,000
Knights Central	Tran.	1912	286,600	£54,427	.....	4.74	647,000
Knights Deep	Tran.	'11–'12	727,700	£177,475	£176,969	3.05	1,477,414
Kyshtim Corp	Sib.	1912	338,379	.....	£296,421	.....	2,565,000
Lahat Mines	Mal	1912	270,927*	£23,687	£23,500	0.65	.....
Lake Copper	U. S.	1912	83,109	—52,441	.....	3.27	.....
Lancaster West	Tran.	1912	247,390	—£492	.....	5.30	335,500
La Rose	Can.	1912	.....	1,023,142	1,000,547	.....	.....
LeRoi No. 2	Can.	'11–'12	.....	40,112	58,320	12.18	.....
Lonely Reef	Rhod.	1912	37,655	£81,860	£81,302	10.11	124,142
Lucky Tiger	Mex.	1912	69,595	711,681	336,208	12.99	152,411
Main Reef West	Tran.	'11–'12	185,731	£84,045	£73,678	5.85	685,720
Mason & Barry	Port.	1912	350,733	£85,665	£64,810	.....	.....
Mason Valley	U. S.	1912	98,912	.....	.....	.....	.....
May Consolidated	Tran.	1912	169,080	£62,759	£72,187	3.99	133,000
McKinley-Darragh-Savage	Can.	1912	70,370	1,153,848	1,123,846	4.44	152,800
Mex. Mines of El Oro	Mex.	'11–12'	142,205	.....	£144,000	5.95	395,000
Meyer & Charlton	Tran.	1912	168,970	£160,107	£120,000	5.80	363,548
Miami	U. S.	1912	1,040,744	2,094,805	1,100,112	3.06	20,800,000
Moctesuma Copper Co.	Mex.	1912	628,012	5,087,201	2,118,570	.....	.....
Modderfontein B	Trans.	1912	388,570	£272,136	£140,000	5.67	2,594,000
Mohawk	U. S.	1912	787,941	656,435	350,000	1.61	.....
Montana-Tonopah	U. S.	'11–'12	53,874	214,375	160,000	8.77	32,000
Morning	U. S.	1912	402,600	324,790	.....	4.35	.....
Mt. Bischoff Tin	Tas.	½–1912	117,328	£42,135	£39,000	1.46	.....
Mt. Boppy	N. S. W.	1912	53,990	5,922	.....	7.06	208,597
Mt. Elliott	Aus.	'11–'12	39,333	£158,443	£110,638	27.70	455,000
Mt. Lyell	Tas.	½–1912	161,908	.....	.....	6.74	4,044,934
Mt. Morgan	Aus.	'11–'12	351,857	.....	£200,000	10.44	3,526,000
Mysore	Ind.	1912	299,660	£428,083	£381,250	7.74	1,337,998
Namaqua Copper	Cape.	1912	38,335	£78,264	£70,748	.....	99,598
Nevada Con	U. S.	1912	2,852,515	4,823,839	3,998,837	2.57	38,853,551
Nevada Hills	U. S.	1912	29,984	438,909	.....	9.60	.....
New Goch	Tran.	1912	324,399	£58,911	.....	4.10	957,571
New Heriot	Tran.	1912	137,680	£104,287	.....	$5.32	590,743
New Kleinfontein	Tran.	1912	549,730	£223,919	£121,250	4.87*	1,190,663
New Primrose	Tran.	1912	289,000	£175,580	£178,750	3.83*	413,037
New Reitfontein	Tran.	1912	189,287	£38,783	£45,756	5.24*	135,888
New Unified	Tran.	1912	132,100	£56,490	£50,000	5.16*	275,022

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Cost per Ton.	Ore Reserves Tons.
New York & Honduras Rosario	Hond.	'11–'12	39,258	179,890	70,000	.....	352,716
Nigel	Tran.	1912	156,500	£34,831	£23,310	6.23	178,765
Nipissing	Can.	1912	.....	.....	1,800,000	.....	188,477
North Butte	U. S.	1912	425,248	.....	697,000	.....	710,920
North Star	U. S.	1912	101,181	.....	300,000	.....	.....
Nourse	Tran.	'11–'12	609,750	£224,623	.....	5.45	1,969,000
Nundydroog	Ind.	1912	100,562	£133,578	£117,916	9.54	138,440
Noregum	Ind.	1912	145,558	£149,969	£120,231	6.61	.....
Oriental Con	Cho.	'11–'12	342,956	672,720	644,085	2.53	802,280
Oroyo-Black Range	Aus.	'11–'12	41,800	.....	.....	6.37	.....
Oroyo Links	Aus.	1912	131,880	172,800	135,000	4.83	114,537
Osceola	U. S.	1912	1,246,557	1,163,289	1,153,800	1.53	.....
Ouro Preto	Bras.	1912	68,486	£9,235	£3,663	6.93	.....
Pahang Con	Mal.	'11–'12	102,797	.....	.....	6.04	.....
Penhalonga	Rhod.	1912	45,233	£9,006	.....	4.39	42,824
Poderosa	Chile	1912	11,318	£54,705	.....	41.18	15,760
Portland	U. S.	1913	173,361	325,510	240,000	.....	.....
Prestea Block A	W. Af.	1912	172,319	.....	.....	7.68	835,014
Princess Estate	Tran.	1912	281,769	—£1,000	.....	6.27	637,000
Quincy	U. S.	1912	1,309,253	960,770	550,000	1.85	.....
Ray Con	U. S.	1912	1,565,875	1,929,262	.....	2.34	80,656,973
Resende	Rhod.	1912	49,380	£16,011	£17,764	.....	101,570
Rio Tinto	Spain	1912	2,406,969	£1,929,144	£1,759,750	.....	.....
Robinson	Tran.	1912	579,950	£697,545	£618,750	4.72	2,533,180
Robinson Deep	Tran.	1912	594,800	£361,163	£325,000	4.46	1,141,000
Roodepoort United	Tran.	1912	362,439	£42,710	.....	4.37	379,283
Rooiberg Minerals	Tran.	'11–'12	20,799	£33,547	£27,000	16.84	21,300
Rose Deep	Tran.	1912	782,200	£410,358	£315,000	4.46	3,695,100
Round Mountain	U. S.	'11–'12	54,015	70,202	.....	4.96	145,820
Santa Gertrud	Mex.	'11–'12	289,839	£252,421	£205,200	6.83	586,000
San Toy	Mex.	1912	7,324	.....	60,000	.....	.....
Selukwe & Columbia	Rhod.	'11–'12	29,929	£1,397	.....	9.30	.....
Seoul Mining	Cho.	1912	74,432	356,347	180,000	3.52	.....
Shannon	U. S.	'11–'12	263,975	150,000	.....	.....	.....
Sheba Gold Mines	Tran.	'11–'12	68,865	£42,796	£40,460	7.43	127,000
Simmer Deep	Tran.	1912	595,656	£35,546	.....	3.97	1,430,693
Snowstorm	U. S.	1912	71,992	88,778	75,000	8.12	.....
Sons of Gwalia	Aus.	1912	155,603	£59,493	£69,062	6.48	.....
Spassky Copper	Sib.	'11–'12	23,759	£162,735	£148,832	41.60	.....
Standard Con	U. S.	1912	16,569 tailings 8,150 ore	7,730	17,893	.....	.....
Stewart	U. S.	1912	179,505	395,347	.....	5.99	.....
St. John del Rey	Bras.	'11–'12	192,600	.....	£64,626	7.88	1,000,000
Sudan Goldfield	S. Af.	1912	14,826	£513	.....	11.45	27,000
Sulphide Corp	Aus.	'11–'12	218,365	£311,227	£278,750	.....	2,499,000
Superior	U. S.	1912	172,322	.....	.....	.....	.....
Talisman Con	N. Z.	'11–'12	47,920	£113,532	£119,898	12.52	56,791
Tasmania Gold	Tas.	'11–'12	51,839	—£4,165	.....	8.90	.....
Tekka	Mal.	1912	889,845*	35,625	30,000	.....	.....
Temiskaming	Can.	1912	.....	.....	300,000	.....	.....
Tennessee	U. S.	1912	444,289	1,095,875	1,000,000	.....	3,691,000
Tharsis Sulphur	Spain	1912	364,802	253,066	250,000	.....	.....
Thistle-Etna	Rhod.	1912	7,300	.....	.....	.....	.....
Tomboy	U. S.	'11–'12	107,577	450,941	148,800	5.17	490,000
Tonopah-Belmont	U. S.	1912	43,478	.....	.....	7.71	563,924
Tonopah Extension	U. S.	'12–'13	54,618	.....	47,172	8.62	.....
Tonopah Mining	U. S.	'12–'13	173,336	.....	1,600,000	7.19	200,702
Treasury Gold	Tran.	'11–'12	80,133	£5,832	.....	.....	.....
Trethewey	Can.	1912	.....	127,834	100,000	.....	31,172
Trimountain	U. S.	1912	336,663	.....	300,000	2.25	.....
Troitzk Gold	Sib.	1912	23,793	—£14,028	.....	.....	26,270
Tronoh	Mal.	1912	496,495	£157,798	£120,000	1.88	.....
Tuolumne	U. S.	1912	46,683	.....	.....	$2.95	.....
U. S. S. R. & M. Co.	U. S.	1912	1,166,857	4,232,965	2,579,882	.....	.....
Utah Apex	U. S.	'11–'12	82,064	.....	.....	.....	100,000
Utah Con	U. S.	1912	183,386	.....	450,000	.....	287,600
Utah Copper	U. S.	1912	5,315,321	6,307,243	4,729,747	.....	257,584,500
Van Roi	Can.	1912	54,115	.....	.....	4.00	.....
Van Ryn	Tran.	'11–'12	460,740	£222,597	£225,000	4.39	2,064,444
Village Deep	Tran.	1912	596,900	£269,708	£185,617	5.04	2,235,300
Village Main Reef	Tran.	1912	470,981	£443,175	£165,200	5.02	.....
Vogelstruis Estate	Tran.	'11–'12	125,128	£7,236	.....	6.05	120,120

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Cost per Ton.	Ore Reserves Tons.
Waihi	N. Z.	1912	147,828	£94,281	£148,772	7.84	760,824
Waihi Grand Junction	N. Z.	1912	41,712	100,000	.....	.....	187,738
Wanderer	Rhod.	'11–'12	219,400	£7,902	.....	1.88	350,925
Wasp No. 2	U. S.	1912	158,200	115,519	85,000	1.24	.....
West Rand Con	Tran.	1912	334,420	£67,720	.....	5.64	1,116,731
Wettlaufer-Loraine	Can.	1912	17,068	283,318	.....	11.61	.....
Winona	U. y.	1912	181,148	—84,871	.....	2.37	.....
Witwatersrand Deep	Tran.	1912	451,000	£178,522	£131,500	4.85	1,492,257
Witwatersrand Gold	Tran.	1912	453,989	£149,710	£148,750	4.19	1,231,540
Wolverine	U. S.	'11–'12	401,308	.....	600,000	1.58	.....
Worchester Exploration	Tran.	1912	59,293	£16,851	£16,751	3.78	110,800
Yukon Gold	Alas.	1912	8,297,363*	1,272,591	1,050,000	0.47	.....
Zinc Corporation	Aus.	1912	345,425	£232,831	£206,433	.....	1,844,745

Note.—Abbreviations used in above table: Alas., Alaska; Aus., Australia; Bras., Brasil; Can. Canada; Cape, Cape Colonies; Cho., Chosen; Eng., British Isles (Cornwall); Hon., Honduras; Ind. India; Mal., Malay States; Mex., Mexico; N. S. W., New South Wales; N. Z., New Zealand; Port. Portugal; Rhod., Rhodesia; Russ., Russia; Sib., Siberia; S. Af., South Africa; Tas., Tasmania; Tran. Transvaal; U. S., United States; W. Af., West Africa.
— Loss for the year. * Cubic yards. All profits and dividends are in dollars except where otherwise noted.

The accompanying tabulation of data obtained from annual reports and abstracts of annual mining reports published in the principal mining magazines, was compiled for the purpose of securing relative data on the costs of production of the various metal-mining companies operating in different parts of the world.

These data cover for the most part the calender and fiscal years ending in 1912, since the reports of many mining companies for the year 1913 will not be published in time to cover the year 1913 at this date.

The column headed "tonnage produced" refers to the tons of ore actually shipped to the smelters or treated locally and does not include waste which was sorted out of the ore hoisted. Some English companies use the long ton of 2240 lb., but as no distinction is made between the long and short ton in many of the abstracts published, there has been no attempt to distinguish between same in this table. However, it is generally probable that the Australian companies are speaking of long tons, the American of short, while the others may use either.

Where sufficient data were given to enable it to be done, the profits are figured as the amount remaining after all expenses of operation, administration, depreciation, development, taxes, etc., were paid. Such money as was put into the capital account, however, is not included.

In figuring the cost per ton, all items in the nature of expenses of operation, administration, depreciation, etc., are included exactly as in the case of computing the profits.

The reserves are, of course, those given in the official report as the number of tons of ore remaining blocked out at the end of the year under review. Probable ore is not so included, neither is that portion of the vein which, though blocked out, is too low grade to return a profit.

AUSTRALASIA

In the following tables the production of minerals and metals in each of the Australian States and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the States are not separately treated, the combined statistics of the Commonwealth now being officially reported. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF NEW SOUTH WALES. (*a*)
(In metric tons or dollars; £1 = $5.) (*b*)

Year.	Alunite.	Antimony and Ore.	Bismuth Ore.	Chrome Ore.	Coal.	Coke.	Cobalt Ore.	Copper Ore.
1899.....	935	332	16	5,327	4,670,580	98,074	193	445
1900.....	1,946	252	11	3,338	5,595,879	128,238	145	867
1901.....	3,196	90	21	2,523	6,063,921	130,944	112	655
1902.....	3,702	58	10	508	6,037,083	128,902	35	3,190
1903.....	2,524	13	23	1,982	6,456,523	163,161	155	1,750
1904.....	376	111	41	404	6,116,126	173,742	6	2,470
1905.....	2,745	394	56	53	6,738,252	165,568	*Nil.*	487
1906.....	1,886	2,490	25	15	7,748,384	189,038	*Nil.*	(*g*)
1907.....	2,021	1,780	17	30	8,796,451	258,683	*Nil.*	(*g*)
1908.....	1,099	119	9	*Nil.*	9,293,377	288,413	*Nil.*	(*g*)
1909.....	3,556	97	9	*Nil.*	7,132,548	207,553	*Nil.*	(*g*)
1910.....	1,154	99	7	*Nil.*	8,304,693	286,854	10	(*g*)
1911.....	1,023	168	9	*Nil.*	8,831,175	268,935	*Nil.*	(*g*)
1912.....	3,479	64	6	*Nil.*	10,044,487	245,050	*Nil.*	(*g*)
1913.....	2,269	18	9	*Nil.*	10,587,734	303,585	*Nil.*	(*g*)

Year.	Copper Matte, Ingot and Regulus.	Diamonds. *carats.*	Gold. (*b*)	Lead, Argentiferous. (*f*)		Lead. Pig. (*f*)	Molybdenite.	Opal.
				Ore.	Metal. (*e*)			
1899....	5,574	25,874	$7,899,075	431,126	20,614	(*d*)4,896	.....	$675,000
1900....	6,243	9,828	5,211,097	426,480	19,400	(*d*)6,807	.....	400,000
1901....	6,184	9,322	3,587,040	406,560	17,191	(*d*)3,394	.....	600,000
1902....	5,560	11,995	3,333,064	371,496	15,660	(*d*)4,685	16	700,000
1903....	8,094	12,239	5,255,421	335,870	18,779	(*d*)3,561	31	500 000
1904....	6,654	14,296	5,576,966	373,362	30,212	(*d*)5,977	26	285,000
1905....	7,899	6,354	5,669,099	420,266	28,244	214	20	295,000
1906....	9,911	2,827	5,249,762	377,890	22,573	60	34	282,500
1907....	10,260	2,539	5,112,852	441,024	20,687	20,084	22	395,000
1908....	9,215	2,205	4,646,451	364,488	(*h*)	15,174	9	209,000
1909....	7,078	5,474	4,231,211	273,628	(*h*)	15,724	29	309,000
1910....	13,096	3,606	4,011,055	322,780	(*h*)	21,534	50	331,000
1911....	12,295	5,771	3,743,672	343,902	(*h*)	17,552	21	286,500
1912....	11,211	2,239	3,416,560	350,850	(*h*)	17,528	57	170,349
1913....	9,619	5,573	3,093,331	397,783	(*h*)	23,947	80	143,513

Year.	Platinum. Kg.	Oil Shale.	Silver—Kg. (f)	Tin.		Tungsten Ore.	Zinc. (c) (f)
				Ore.	Block.		
1899.....	19.8	37,307	21,525	5	749	.....	50,677
1900.....	15.6	23,229	24,080	15	1,087	.....	20,594
1901.....	12.1	55,650	13,950	11	659	.....	642
1902.....	11.6	63,886	33,195	23	502	.....	1,231
1903.....	16.5	35,332	34,195	556	949	9	21,088
1904.....	16.6	38,477	34,880	586	1,084	106	58,523
1905.....	12.4	38,838	12,987	726	817	228	105,189
1906.....	6.4	32,965	8,865	(h)	1,698	245	105,325
1907.....	8.6	48,088	63,573	(h)	1,945	409	241,015
1908.....	4.2	47,044	77,490	(h)	1,823	247	281,147
1909.....	13.7	49,500	53,430	(h)	1,974	129	379,907
1910.....	10.3	69,385	55,176	(h)	1,898	168	476,125
1911.....	14.6	76,306	54,975	(h)	1,960	288	524,866
1912.....	19.0	87,399	74,314	(h)	2,107	231	528,872
1913.....	13.7	17,268	68,267	(h)	3,071	172	515,105

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported £1 = $4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver-sulphide. (f) Exported. In the case of lead, 101,811 long tons were produced in 1912 from N. S. Wales in Australia; see article on lead. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND. (a)
(In metric tons or dollars; £1 = $5.)

Year.	Bismuth Ore.	Coal.	Copper.	Gold (b).	Lead.	Manganese Ore.
1899.....	2	501,913	164	$19,571,662	57	747
1900.....	8	505,252	386	20,002,290	207	77
1901.....	20	548,104	3,110	12,367,276	570	221
1902.....	1	509,579	3,845	13,238,500	271	4,674
1903.....	11	515,950	4,995	13,818,653	3,856	1,341
1904.....	20	520,232	4,440	13,210,869	2,079	843
1905.....	15	537,795	7,337	12,249,157	2,464	1,541
1906.....	7	610,480	10,238	11,257,316	2,854	1,131
1907.....	6	694,204	12,959	9,641,789	5,240	1,134
1908.....	22	707,473	14,932	9,613,051	7,207	1,403
1909.....	11	768,720	14,727	9,416,576	5,323	613
1910.....	22	885,108	16,649	9,123,531	2,435	805
1911.....	10	905,568	20,709	7,981,791	1,799	1,167
1912.....	(c) 201	917,202	23,505	7,191,846	3,179	313
1913.....	185	1,045,243	24,050	5,492,585	3,663	27

Year.	Molybdenite.	Opal.	Silver. Kg.	Tin Ore.	Tungsten Ore.
1899.....	.....	$45,000	4,521	1,322	263
1900.....	.....	37,500	3,514	1,133	193
1901.....	.....	37,000	17,777	1,638	73
1902.....	(c) 42	35,000	21,813	2,118	58
1903.....	(c) 24	36,500	19,972	3,768	200
1904.....	(c) 22	17,750	20,370	3,986	1,564
1905.....	64	15,000	18,716	4,008	1,434
1906.....	108	15,000	24,357	4,900	785
1907.....	68	15,000	28,662	5,222	627
1908.....	89	12,500	36,200	4,903	426
1909.....	94	10,000	31,140	3,379	617
1910.....	108	15,000	26,787	3,000	869
1911.....	(c) 232	15,000	17,076	3,140	548
1912.....	104	14,600	17,712	3,284	636
1913.....	68	14,600	18,805	4,251	364

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold is reported £1 = $4.866. (c) Includes bismuth and some tungsten.

MINERAL PRODUCTION OF SOUTH AUSTRALIA.
(In metric tons or dollars.) (*a*)

Year.	Copper.		Gold. (*b*)	Iron Ore.	Lead.	Lime-stone.	Phosphate Rock.	Salt.	Other Metals and Minerals.
	Ore.	Metal.							
1900.....	2,405	4,964	$70,528	.....	389	.....	.....	.....	$2,055
1901.....	1,896	6,844	80,839	.....	69	.....	.....	.....	11,095
1902.....	2,620	6,956	121,056	.....	2,210	.....	.....	.....	3,710
1903.....	7,182	6,594	139,411	86,291	732	.....	1,016	40,640	500
1904.....	3,100	6,378	369,938	47,434	.....	44,135	3,048	40,640	990
1905.....	2,604	6,653	223,121	85,835	53	45,210	5,080	33,020	6,305
1906.....	535	8,339	131,382	76,430	51	32,451	5,944	55,880	11,045
1907.....	.....	8,058	99,948	85,954	.....	31,598	8,128	76,200	12,500
1908.....	.....	5,718	59,852	89,412	.....	29,973	11,177	76,204	22,500
1909.....	1,250	5,788	146,982	16,379	142	13,986	3,833	52,232	19,365
1910.....	.....	5,184	136,248	46,939	406	18,898	5,283	54,862	68,000
1911 (*a*)..	.....	6,017	72,990	42,976	.....	29,159	5,893	66,040	56,600
1912.....	.....	6,395	136,248	42,877	.....	51,412	6,198	65,338	51,044
1913.....	.....	7,174	134,275	61,669	.....	45,038	6,049	66,083	104,906

(*a*) From *Review of Mining Operations* by Hon. Richard Butler, Adelaide, 1911. (*b*) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF TASMANIA. (*a*)
(In metric tons or dollars.) (*b*)

Year.	Coal.	Copper Ore.	Blister Copper.	Gold. (*b*)	Iron Ore.	Lead-Silver Ore.	Tin Ore.
1900.....	51,549	4,221	9,343	$1,538,727	5,141	453,519	2,693
1901.....	49,963	11,401	10,141	1,436,326	1,422	804,463	2,516
1902.....	49,647	8,630	7,869	1,467,454	2,424	47,226	1,989
1903.....	49,856	3,891	6,791	1,237,925	6,076	43,103	2,414
1904.....	62,090	(*d*)	8,826	1,362,587	6,950	51,959	2,104
1905.....	52,825	(*d*)	9,919	1,520,101	6,401	76,424	3,953
1906.....	53,742	2,270	8,847	1,240,650	2,642	88,513	4,545
1907.....	59,833	1,261	8,378	1,360,836	3,048	91,216	4,412
1908.....	62,044	1,204	8,974	1,179,950	3,657	62,022	4,593
1909.....	67,224	1,613	8,472	951,005	*Nil.*	81,668	4,583
1910.....	83,763	682	8,324	765,784	*Nil.*	52,047	3,760
1911.....	57,980	2,323	6,118	628,375	*Nil.*	62,489	4,016
1912.....	54,366	1,414	5,218	784,320	*Nil.*	91,570	3,773
1913.....	55,043	1,967	4,569	690,369	*Nil.*	83,289	4,010

(*a*) From *Statistics of the Colony of Tasmania.* (*b*) Where value of gold is reported, £1 = $4.866. (*c*) Included with lead-silver ore. (*d*) Not reported.

MINERAL PRODUCTION OF NEW ZEALAND. (*a*) (*b*)
(In metric tons or dollars.) (*c*)

Year.	Anti-mony.	Chrome Ore.	Coal.	Coke.	Copper Ore	Gold. (*c*)	Kauri-gum.	Manga-nese Ore.	Silver. *Kg.*
1900...	3	28	1,111,880	.....	12	$7,005,103	10,322	166	10,202.0
1901...	30	.....	1,247,341	.....	3	8,533,908	7,662	211	17,762.0
1902...	.....	128	1,383,511	.....	.....	9,495,673	7,549	.....	20,970.3
1903...	.....	.....	1,442,937	.....	6	9,916,086	9,507	71	28,364.3
1904...	.....	.....	1,562,520	.....	.....	9,671,180	9,203	196	34,042.3
1905...	.....	.....	1,611,207	15	4	10,189,093	10,883	55	36,695.0
1906...	.....	.....	1,757,234	5	.....	11,050,219	9,300	16	43,251.5
1907...	100	.....	1,860,397	15	57	9,865,766	8,847	5	48,603.5
1908...	5	.....	1,890,844	2	13	9,755,303	5,618	*Nil.*	53,834.8
1909...	2	*Nil.*	1,941,923	23	5	9,765,575	8,382	6	56,410.0
1910...	*Nil.*	*Nil.*	2,232,610	*Nil.*	*Nil.*	9,227,532	8,832	5	52,176.8
1911...	20	*Nil.*	2,099,234	*Nil.*	*Nil.*	9,105,000	7,587	1	40,775.2
1912...	.....	.....	2,177,615	4	*Nil.*	6,427,422	7,908	.....	24,237.8
1913...	.....	.....	1,919,472	28	.....	7,101,822	8,926	.....	30,344.6

(*a*) From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines. Wellington. (*b*) The exports are stated to be identical with the production, with the exception of coal. (*c*) Where gold is reported £1 = $4.866. (*d*) Exports.

MINERAL PRODUCTION OF VICTORIA. (a)
(In metric tons or dollars.)

Year.	Coal.	Lignite.	Gold. (c)	Building Stone, etc.	Tin Ore.
1899.....	266,578	(b)	$17,662,410	(b)	158
1900.....	215,052	(b)	16,767,261	$175,000	71
1901.....	212,678	152	16,320,029	225,000	78
1902.....	228,777	(b)	14,899,876	266,975	10
1903.....	65,230	5,752	15,860,815	213,245	34
1904.....	123,695	*Nil.*	15,824,952	1,488,075	72
1905.....	157,648	*Nil.*	15,443,438	(b)	126
1906.....	163,201	*Nil.*	15,962,804	(f) 362,725	108
1907.....	140,802	*Nil.*	14,377,166	(f) 401,090	105
1908.....	115,283	*Nil.*	13,867,312	(f) 453,075	80
1909.....	130,230	*Nil.*	13,522,400	397,645	90
1910.....	374,775	660	11,789,077	574,775	42
1911.....	664,326	6,232	11,789,077	75,063	33
1912.....	598,599	4,076	9,924,032	.....	48
1913.....	603,811	3034	9,189,593	.....	58

(a) From annual Reports of the Secretary for Mines of the Colony. (b) Not reported. (c) Where gold is reported, £1 = $4.866. (e) Estimated value. (f) Includes crude salt.

MINERAL PRODUCTION OF WESTERN AUSTRALIA. (a)
(In metric tons or dollars.)

Year.	Tungsten Ore.	Coal.	Copper Ore.	Copper and Matte.	Gold. (b) (c)	Iron Ore.	Lead Ore.	Silver. *Kg.*	Tin Ore.
1903.....	.....	135,568	20,854	.....	$40,560,927	224	*Nil.*	5,229	830
1904.....	.....	140,773	4,033	.....	39,557,933	1,465	*Nil.*	12,416	889
1905.....	.....	129,402	2,389	.....	38,045,366	3,264	*Nil.*	11,189	1,096
1906.....	.....	152,151	7,548	(f)3,676	35,888,278	1,300	*Nil.*	8,776	1,518
1907.....	.....	144,651	19,282	1,628	35,087,500	1,112	(d) 214	5,887	(e) 1,526
1908.....	.....	178,061	8,427	486	34,061,426	*Nil.*	(d) 526	5,240	(e) 1,111
1909.....	1	217,741	7,071	846	32,973,349	*Nil.*	(d) 214	5,500	(e) 709
1910.....	2	266,361	6,410	1,301	30,397,162	10	252	5,478	506
1911.....	10	253,900	9,974	832	28,331,272	*Nil.*	884	5,215	503
1912.....	*Nil.*	299,815	9,733	1,730	26,511,840	*Nil.*	11,276	4,293	585
1913.....	1	319,048	(g)4,401	(g)83	26,851,459	*Nil*	(g)3,169	5,847	(h)484

(a) From the *Report of the Department of Mines of Western Australia.* (b) £1 = $4.866. (c) The value of gold produced in 1895 was $4,280,855; in 1896, $5,200,821; in 1897, $12,481,176; in 1898, $19,418,735; in 1899, $30,396,593; in 1900, $27,461,865. (d) Silver-lead and lead ore. (e) Includes ingots. (f) Total in previous years. (g) Exports. (h) Ore and Ingot.

MINERAL IMPORTS OF AUSTRALIA. (a)
(In metric tons, cwts. of 112 lb., or dollars; £1 = $5.) (b)

Year.	Cement. *Cwts.*	Coal.	Coke.	Copper Ore. *Cwts.*	Gold. (b)				
					Ore.	Bullion.	Specie.	Foil. (c)	Total Value
1903	954,606	389	4,294	5	$66,908	$5,935,800	$6,530	$38,680	$6,047,918
1904	561,237	398	4,270	12	68,309	5,684,164	6,297	43,215	5,801,985
1905	700,245	7,866	5,553	80	103,709	7,067,534	422,127	52,144	7,645,514
1906	793,928	706	6,202	873	93,116	10,053,463	397,990	53,356	10,597,925
1907	513,326	14,973	9,981	3,652	136,520	6,942,940	48,499	45,283	7,173,245
1908	915,033	14,833	10,368	3,959	42,855	4,625,498	70,197	.....	4,738,553
1909	848,337	16,044	44,668	4,533	36,670	4,865,436	56,280	118,240	5,076,620
1910	1,612,004	314,374	17,161	23,027	35,991	4,634,553	126,556	.....	(c)4,816,100
1911	1,670,117	10,498	22,608	10,201	59,613	7,707,920	124,248	.....	7,891,781
1912	2,603,792	16,152	15,839	18,449	93,885	5,478,177	1,190,890	.....	6,762,952
1913	2,511,828	4,928	27,304	25,085	121,520	5,856,910	935,125	201,645	7,115,200

Year.	Graphite Cwts.	Iron and Steel. Bars, Rods Girders, Sheets etc. Cwts.	Iron and Steel. Galvanised Plates and Sheets. Cwts.	Iron and Steel. Pig and Scrap. Cwts.	Lead Mfrs. Cwts.	Petroleum Products. Kerosene. Gal.	Petroleum Products. Naphtha Gal.	Petroleum Products. Paraffin.
1903..	5,557	1,211,437	886,570	989,998	9,525	15,009,609	127,445	2,163
1904..	4,263	1,399,783	1,027,859	883,397	6,243	14,791,319	277,737	530
1905..	4,386	1,482,334	1,112,467	940,757	8,859	16,416,734	292,670	.....
1906..	6,531	1,878,851	1,245,211	1,220,236	14,830	15,473,570	488,961	.....
1907..	6,991	2,045,184	1,502,790	1,276,566	2,940	19,273,955	683,679	2,578
1908..	.....	2,153,528	(d)1,253,624	820,834	2,703	17,154,940	782,859	1,560
1909..	.....	2,559,798	(d)1,658,291	1,178,219	19,338	19,924,622	884,703	2,767
1910..	£9,951	3,663,386	2,131,911	1,073,933	9,111	19,660,890	1,339,381	3,963
1911..	£7,782	4,212,986	2,177,961	1,574,439	1,820	19,378,540	1,772,840	3,314
1912..	£8,629	4,933,414	2,416,367	1,719,585	1,194	24,292,539	12,294,617	2,832
1913..	£9,578	5,070,590	2,196,865	1,535,030	2075	19,288,122	8,812,771	2,793

Year.	Potassium Nitrate. Cwts.	Quicksilver.	Salt. Cwts.	Silver. (b) Ore. Cwts.	Silver. (b) Bullion. Kg.	Silver. (b) Specie.	Sulphur. Cwts.	Spelter, Sheets, Concentrates Dross, etc. Cwts.
1903.....	4,659	87.5	312,681	.....	14.2	160,111	180,719	14,197
1904.....	7,812	92.6	355,599	.....	39.8	154,534	252,744	23,316
1905.....	9,010	82.1	492,727	.....	3908.0	261,397	177,304	26,211
1906.....	8,112	78.6	326,042	380	9756.4	703,820	269,704	24,233
1907.....	8,571	59.5	409,852	2	11.4	1,829,309	264,060	24,026
1908.....	6,036	56.4	390,535	.....	189.8	1,019,738	420,098	38,724
1909.....	6,894	58.1	234,092	.....	622.1	157,352	405,396	59,475
1910.....	7,016	57.0	444,081	14,609	1,412.0	1,615,775	357,332	70,658
1911.....	10,257	41.5	753,849	17,340	1,580.3	1,647,830	386,764	86,601
1912.....	10,127	53.0	475,967	3,863	1,580.3	1,350,870	465,643	29,245
1913.....	10,552	460.0	533,055	10,396	10,763.0	861,500	560,065	9,437

(a) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (b) Where gold or silver values are reported, £1 = $4.866. (c) Includes silver and other foils. (d) Includes ungalvanised corrugated. (e) Includes $19,000 in matte

MINERAL EXPORTS OF AUSTRALIA. (a)

(In metric tons, cwts. of 112 lb., or dollars; £1 = $5.)

Year.	Alunite. Cwts.	Antimony Ore. Cwts.	Bismuth Ore. Cwts.	Cement. Cwts.	Chrome Ore. Cwts.	Coal.	Coke.	Cobalt Ore. Cwts.	Copper. Ore. Cwts.	Copper. Ingot and Matte. (Cwts.)
1903.	49,690	947	832	11,168	39,022	2,063,016	27,345	3,060	61,569	616,277
1904.	7,400	2,177	1,918	26,305	7,941	1,637,113	2,771	167	90,098	540,998
1905.	54,040	7,811	2,222	17,283	(c)	2,058,190	2,316	1,320	17,380	632,183
1906.	37,120	66,188	1,574	39,737	(c)	2,094,793	11,382	.....	33,476	744,357
1907.	41,750	74,440	653	75,600	54,503	2,689,917	35,063	.....	157,071	853,236
1908.	21,640	23,931	1,396	49,116	22,300	2,601,944	28,068	.....	103,694	765,298
1909.	73,795	14,976	1,763	23,585	.....	1,608,181	24,798	280	163,612	676,664
1910.	23,290	12,796	1,456	34,259	.....	1,730,375	10,457	186	209,611	769,745
1911.	20,272	17,985	2,307	45,247	.....	1,714,947	8,492	.....	263,078	806,005
1912.	68,500	30,894	610	27,724	453	2,186,930	9,852	.....	(f)295,751	876,773
1913.	44,700	51,007	588	18,221	.....	2,129,982	8,154	.....	177,757	846,411

Year.	Gold. (b)				Iron and steel bars, rods, etc. *Cwts.*	Lead.		
	Ore.	Bullion.	Specie.	Total Value.		Pig and matte. *Cwts.*	Argentiferous. *Cwts.*	Manufactures *Cwts.*
1903....	80,591	$29,691,889	$53,634,629	$83,407,109	5,753	633,816	553,308	28,783
1904....	46,894	27,073,767	49,284,833	76,405,494	4,952	1,626,292	790,435	20,552
1905....	49,507	25,788,574	27,523,288	53,361,369	4,821	1,302,428	753,008	34,629
1906....	20,296	24,113,950	47,937,681	72,071,927	11,560	1,031,605	781,426	20,358
1907....	17,513	(c) 19,639,502	33,370,240	53,027,255	13,163	1,774,207	.....	21,765
1908....	20,539	(c) 18,924,716	50,794,544	69,739,799	13,015	2,132,199	.....	20,161
1909....	270,131	(c) 17,265,872	26,028,555	43,564,558	12,040	1,381,369	.....	14,087
1910....	429,288	(c) 11,970,906	10,598,747	22,998,940	17,106	1,800,856	845,856	13,350
1911....	327,101	10,456,322	47,831,267	58,614,700	117,131	1,755,650	430,073	14,619
1912....	340,474	(c) 9,135,487	50,801,322	60,277,283	134,201	1,438,681	502,264	17,916
1913....	1,164,146	6,695,757	10,184,007	18,043,910	187,330	1,529,075	524,513	14,989

Year.	Molybdenum Ore. *Cwts.*	Salt. *Cwts.*	Shale oil.	Silver.		Tin.		Spelter, Sheets, Concentrates, Dross, etc. *Cwts.*
				Ore. (d) *Cwts.*	Bullion. *Kg.*	Ore. *Cwts.*	Block. *Cwts.*	
1903.....	783	155,613	14,483	1,653,794	202,730	26,900	82,473	60,206
1904.....	1,100	141,553	8,202	2,235,385	227,972	40,339	99,476	309,422
1905.....	1,381	174,987	11,818	581,651	208,134	55,153	108,963	3,006,372
1906.....	1,867	198,851	7,203	1,010,707	174,457	51,793	130,120	2,592,018
1907.....	2,025	189,194	5,686	907,790	294,679	65,005	131,407	5,393,784
1908.....	2,116	240,348	19,173	1,137,746	326,250	49,409	121,979	6,235,024
1909.....	1,055	230,486	3,983	1,914,479	90,989	8,559	111,262	6,994,745
1910.....	1,972	184,892	9,307	(f) 2,524,487	137,916	40,469	87,529	8,161,081
1911.....	1,876	63,607	6,344	(f) 3,226,043	(e) 218,388	(f) 55,721	82,935	8,648,818
1912.....	2,873	123,779	290	(f) 2,395,267	(e) 217,820	(f) 64,704	77,501	9,265,599
1913.....	2,684	134,868	449	(d f) 3,377,901	(e) 229,940	89,384	68,392	9,549,433

(a) From "Trade and Customs Returns," Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (b) Where gold or silver values are reported £1 = $4.866. (c) Included with iron ore. (d) Includes lead ore. (e) Includes that contained in matte. (f) Includes concentrates. (g) Lead contents of matte, etc.

AUSTRIA-HUNGARY

In the following tables the mineral and metal productions of the two Kingdoms are reported separately, together with that of Bosnia and Herzegovina. Figures given in bold face are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA. (a)
(In metric tons.)

Year.	Alum.	Alum and Pyritic Shale.	Antimony.		Asphaltic Rock.	Bismuth Ore.	Coal.	
			Ore.	Metal.			Bituminous.	Lignitic.
1900	620	3,004	201	153	887	4.0	10,992,515	21,539,917
1901	442	2,551	126	114	541	16.0	11,738,840	22,473,510
1902	62	2,866	18	24	897	8.0	11,045,039	22,139,683
1903	*Nil*	2,978	41	14	1,273	10.0	11,498,111	22,157,521
1904	*Nil*	2,337	103	36	1,435	1.7	11,868,245	21,987,651
1905	*Nil*	1,657	1,673	90	4,363	1.7	12,585,263	22,692,076
1906	*Nil*	1,020	1,071	*Nil*	2,840	2.7	13,473,307	24,167,714
1907	*Nil*	*Nil*	910	207	3,858	*Nil*	13,850,420	26,262,110
1908	*Nil*	*Nil*	193	162	3,695	*Nil*	13,875,382	26,728,926
1909	*Nil*	*Nil*	450	*Nil*	2,975	*Nil*	13,713,043	26,043,716
1910	*Nil*	*Nil*	225	*Nil*	1,066	*Nil*	14,056,858	25,157,541
1911	*Nil*	*Nil*	270	.....	1,740	4	14,487,550	25,157,601
1912	.....	.....	4,520	13	4,234	.....	15,797,890	26,283,690
1913	.....	.....	1 270	.....	3,026	.....	16,459,889	27,378,332

Year.	Copper.			Copperas.	Gold.		Graphite.	Iron.	
	Ore.	Metal.	Sulphate.		Ore.	Bullion.		Ore.	Pig & Cast
1900	5,825	881	234	474	$227	$47,183	33,663	1,894,458	879,132
1901	7,406	776	256	472	143	31,234	29,992	1,963,246	884,844
1902	8,455	914	248	271	74	4,652	29,527	1,742,498	991,827
1903	12,688	961	310	298	2,148	5,316	29,590	1,715,984	970,832
1904	10,701	889	808	414	12,653	47,183	28,620	1,719,219	988,364
1905	10,677	870	540	116	35,937	133,218	34,416	1,913,782	1,119,614
1906	20,255	877	578	154	33,033	83,401	38,117	2,253,662	1,222,230
1907	10,400	592	579	*Nil*	30,711	92,471	49,425	2,540,118	1,383,524
1908	8,381	683	556	*Nil*	28,907	98,504	44,425	2,632,407	1,466,897
1909	11,826	985	591	70	29,709	98,295	40,710	2,490,277	1,465,051
1910	8,005	1,468	715	*Nil*	31,744	118,895	33,131	2,627,513	1,504,786
1911	10,974	1,760	767	*Nil*	29,647	134,840	41,599	2,765,815	1,596,148
1912	17,354	3,057	884	40	30,192	134,543	45,375	2,926,686	1,759,850
1913	16,353	3,685	897	40	35,994	186,714	49,456	3,039,324	1,757,864

Year.	Lead.			Manganese. Ore.	Mineral Paint.	Petroleum.	Quicksilver.		Salt.
	Ore.	Pig.	Litharge.				Ore.	Metal.	
1900	14,314	10,650	1,288	8,804	2,828	347,213	94,747	510	330,277
1901	16,688	10,161	1,317	7,796	1,701	404,662	97,360	525	333,238
1902	19,055	11,264	1,023	5,646	1,486	520,845	90,040	511	311,806
1903	22,196	12,162	923	6,179	1,691	672,508	83,321	523	359,015
1904	22,514	12,645	783	10,189	1,829	.....	88,279	536	369,877
1905	23,339	12,968	865	13,788	798	.....	86,856	520	343,375
1906	19,683	14,846	1,059	13,402	943	.....	91,494	526	378,912
1907	22,792	13,598	863	16,756	1,091	.....	89,370	527	395,053
1908	21,513	12,669	1,010	16,656	475	.....	90,145	572	388,133
1909	20,550	12,941	840	18,045	620	.....	92,337	585	359,801
1910	22,841	15,476	602	15,694	698	1,766,018	100,899	603	345,629
1911	23,845	18,097	318	15,954	2,902	1,487,842	111,018	704	342,732
1912	27,952	19,993	301	12,471	2,960	1,144,133	117,780	763	365,789
1913	25,751	22,312	305	16.540	2,999	1,081,090	130,608	820	327,830

Year.	Silver.		Sulphuric Acid.	Sulphur. Ore.	Tin.		Tungsten Ore.	Uranium.		Zinc.	
	Ore.	Bullion. (*Kg.*)			Ore.	Block.		Ore.	Salts.	Ore.	Spelter.
1900.	21,641	39,572	7,067	862	51	40	50	52	11.3	38,243	6,742
1901.	21,363	40,205	7,073	4,911	42	49	45	48	13.0	36,072	7,558
1902.	22,288	39,544	8,781	3,721	47	50	45	46	10.0	31,927	8,309
1903.	21,958	39,812	9,105	4,475	57	34	49	45	6.0	29,544	8,949
1904.	21,949	39,032	8,742	6,288	77	38	52	17	11.0	29,226	9,159
1905.	21,047	38,453	1,007	8,407	52	53	55	16	13.9	29,983	9,326
1906.	21,944	38,940	745	15,125	55	42	56	16	16.1	32,037	10,804
1907.	22,636	38,742	*Nil*	24,099	53	47	44	11	11.2	31,970	11,208
1908.	22,241	39,867	*Nil*	17,429	68	39	37	9	8.4	31,266	12,770
1909.	21,102	39,002	*Nil*	12,725	36	52	39	13	10.2	33,955	11,688
1910.	23,629	49,692	.....	15,839	37	40	40	6.5	10.3	34,637	12,458
1911.	24,143	50,244	.....	15,805	944	15	45	5.8	6.8	32,166	15,766
1912.	21,794	49,000	.....	13,996	606	13	66	11.0	5.0	34,675	17,298
1913.	19,937	54,434	.....	10,561	939	11	52	11.2	4.5	34,225	19,508

(a) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY. (a)
(In metric tons or dollars; 1 crown = $0.203.)

Year.	Antimony.		Asphalt	Asphaltic Rock.	Bismuth.	Carbon Bisulphide.	Coal.			
	Ore.	Regulus.					Bituminous. (*d*)	Lignite. (*d*)	Coke.	Briquets.
1899...	1,965	940	3,060	.....	3.0	1,120	1,238,855	4,292,584	10,336	31,137
1900...	2,373	846	2,700	.....	2.0	1,250	1,447,047	5,128,277	12,973	69,353
1901...	(*b*) 323	706	2,878	25,161	1.6	2,087	1,365,270	5,179,829	10,975	40,182
1902...	(*b*) 748	683	2,774	24,873	0.9	2,320	1,162,785	5,132,053	8,204	88,069
1903...	(*b*) 205	732	2,422	21,552	1.5	2,357	1,233,410	5,271,781	9,442	101,197
1904...	1,080	1,007	2,221	17,660	0.9	2,512	1,155,320	5,519,349	5,103	103,481
1905...	949	756	173	19,372	1.4	2,760	919,193	6,015,452	69,303	144,697
1906...	1,807	954	4,111	34,664	2.0	2,756	1,103,529	6,229,712	79,930	151,657
1907...	2,035	841	3,920	33,096	0.4	2,950	1,038,819	6,408,322	97,447	154,783
1908...	1,316	670	4,818	72,972	(*c*)	2,966	982,017	7,034,499	141,954	109,178
1909...	1,971	695	5,054	.....	.....	3,086	1,397,424	7,658,719	157,415	117,594
1910...	1,939	782	4,994	.....	.....	3,245	1,302,103	7,734,166	156,048	108,873
1911...	2,616	892	3,861	.....	.....	3,488	1,290,182	8,154,560	145,104	118,412
1912...	8,380	859	4,460	.....	.....	3,692	1,302,405	8,287,871	149,913	118,505

Year.	Copper.	Copperas.	Gold.	Iron.			Lead.		Lithargе.	Manganese Ore.
				Ore. (*d*)	Pig.	Cast.	Ore.	Pig.		
1900...	181	700	$2,173,079	1,666,363	432,817	22,738	612	2,030	201	5,746
1901...	162	805	2,189,692	1,557,300	430,686	20,640	(*b*) 10	2,029	238	4,591
1902...	89	909	2,260,135	1,562,238	416,835	18,569	(*b*) 20	2,244	219	7,237
1903...	45	982	2,243,521	1,439,132	396,674	18,875	(*d*)3,698	2,057	257	5,311
1904...	63	1,277	2,437,088	1,524,036	370,297	17,203	(*d*)3,922	2,104	710	11,527
1905...	73	920	2,439,451	1,661,358	403,719	17,563	686	2,146	209	5,708
1906...	69	1,306	2,487,156	1,698,291	402,527	17,164	564	1,925	698	7,176
1907...	85	1,212	2,330,292	(*e*)622,518	423,134	17,103	8	1,468	441	8,198
1908...	166	1,372	2,189,801	(*e*)727,019	505,559	17,415	3	1,544	190	10,601
1909...	265	1,414	1,813,024	1,965,487	514,853	15,577		1,590	625	11,921
1910...	214	1,313	2,022,032	1,905,749	487,421	14,635	91	2,077	570	13,270
1911...	208	849	2,125,241	1,950,231	502,460	15,990	239	1,583	391	14,755
1912...	242	1,364	1,898,771	1,991,162	541,659	11,180	1,212	1,605	328	13,833
1913...	.....	450	1,935,004	.....	.....	.....	.....	.....	.....	.....

Year.	Mineral Paints.	Petroleum.	Pyrite.	Quicksilver. Kg.	Salt.	Silver. Kg.	Sulphur.	Sulphuric Acid.	Zinc.	
									Ore. (b)	Spelter.
1901...	305	3,296	93,907	33,003	215,581	23,636	137	1,464	693	14
1902...	283	4,347	106,490	44,600	217,079	23,020	105	1,193	364	.....
1903...	263	3,010	96,619	43,700	214,536	19,281	135	1,543	46	26
1904...	273	2,134	97,148	45,169	230,943	16,352	143	1,329	203	.....
1905...	196	471	106,848	36,000	238,642	15,946	135	1,410	173	.....
1906...	221	2,692	112,,623	50,100	245,402	13,642	133	1,457	243	146
1907...	259	2,404	99,503	40,400	(c)	12,695	(c)	1,232	(c)	(c)
1908...	294	2,427	95,824	78,000	(c)	12,612	144	1,444	135	(c)
1909...	63	2,590	98,971	71,500	231,182	10,932	131	1,307	(0)	.....
1910...	55	2,501	92,464	90,000	230,315	12,547	128	1,334	280	.....
1911...	69	2,191	96,755	79,700	239,006	10,806	51	938	106	.....
1912...	105	2,793	103,809	84,979	270,929	10,782	83	1,311	777	.....
1913...	.....	.....	.....	.....	.....	8,938	.....	.....	.....	.....

(a) From the *Annuaire Statistique Hongrois*. (b) Includes only that part of the crude output that was not smelted into a refined product. (c) Not reported. (d) Total production. (e) Exported.

MINERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA. (a
(In metric tons.)

Year.	Chrome Ore.	Copper		Iron.		Lignite.	Manganese Ore.	Pyrite.	Quicksilver.	Salt.
		Ore.	Metal.	Ore.	Pig.					
1900...	100	3,008	141	133,454	38,960	394,516	7,939	1,710	6.7	15,791
1901...	505	3,696	199	122,569	39,296	445,007	6,346	4,570	9.3	16,865
1902...	270	3,657	166	133,348	43,992	424,753	5,760	5,170	7.2	17,348
1903...	147	1,073	191	114,059	39,833	467,962	4,538	6,589	8.1	18,459
1904...	279	640	115	127,297	47,678	483,617	1,114	10,412	8.1	18,021
1905...	186	670	39	122,540	43,074	540,237	4,129	19,045	10.0	(b)
1906...	320	765	25	136,513	45,660	594,172	7,651	11,347	5.1	22,671
1907...	310	245	*Nil.*	150,684	48,946	621,179	7,000	7,229	1.2	21,148
1908 (c)	315	(b)	*Nil.*	150,075	48,900	630,500	6,000	(b)	*Nil.*	22,100
1909 (c)	310	(b)	*Nil.*	145,200	48,850	675,400	5,000	(b)	*Nil.*	22,500
1910...	320	(b)	*Nil.*	132,720	48,841	706,659	4,000	571	*Nil.*	23,579
1911...	250	(b)	*Nil.*	140,283	44,354	769,763	3,600	3,118	*Nil.*	22,591
1912...	200	.....	*Nil.*	150,420	53,270	852,920	4,650	6,216	*Nil.*	23,124

(a) From *Oestr. Zeit. f. B.-u. H.* (b) Not reported. (c) Estimated.

MINERAL IMPORTS OF AUSTRIA-HUNGARY. (a)
(In metric tons or dollars; 5 Crowns = $1.)

Year.	Alum.	Aluminium and Alloys.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic. (b)	Asbestos.	
				Ore.	Regulus—Kg.		Crude. (c)	Manufactures.
1900.....	430	154	1,435	46	23,000	320	1,085	1,238
1901.....	413	153	1,882	27	1,500	351	1,678	1,032
1902.....	537	151	2,161	40	18,200	351	2,038	798
1903.....	508	150	2,670	42	87,200	371	3,395	1,221
1904.....	602	231	2,346	64	21,000	384	2,517	1,240
1905.....	774	477	2,775	42	24,700	342	5,962	208
1906(f)..	513	216	2,840	79	38,900	83	7,025	111
1907.....	545	255	3,200	231	89,900	325	5,729	180
1908.....	567	323	2,606	304	128,200	349	9,484	139
1909.....	359	418	1,831	95	80,100	370	12,003	200
1910.....	589	303	1,474	96	121,800	416	11,602	250
1911.....	375	516	1,317	98	124,600	377	16,071	276
1912.....	253	1,224	1,396	91	49,000	24	24,615	338
1913.....	454	589	1,334	.....	.....	47	17,575	248

Year.	Asphalt.		Barytes.	Borax.		Cement.	Chloride of Lime.	Chrome Ore.
	Crude Rock	Mastic and Bitumen.		Crude and Boric Acid.	Refined.			
1900.....	8,301	1,564	5,945	3,056	93	25,747	3,326	2,823
1901.....	5,702	1,106	6,336	1,687	233	23,559	3,326	860
1902.....	5,732	1,273	6,266	2,168	174	18,658	2,596	2,668
1903.....	5,871	1,272	7,057	2,192	150	23,256	2,791	2,121
1904.....	8,211	1,064	6,238	2,752	142	20,259	3,407	1,209
1905.....	8,553	1,139	6,187	3,099	205	21,950	1,847	2,305
1906(S).....	13,381	895	9,654	3,519	126	21,833	2,491	1,612
1907.....	9,394	1,637	11,669	3,763	138	23,697	2,534	2,795
1908.....	11,678	1,305	11,241	4,105	158	39,135	2,395	1,837
1909.....	9,113	1,309	13,940	3,240	139	53,262	3,105	2,223
1910.....	15,897	1,101	21,486	5,284	166	81,251	1,585	1,271
1911.....	18,394	1,990	20,501	4,407	193	80,613	3,131	2,217
1912.....	25,111	4,295	21,375	4,286	482	83,630	2,802	4,329
1913.....	24,794	1,011	23,350	5,652	356	61,261	3,097	2,845

Year.	Kaolin and Feldspar.	Coal.		Coke.	Copper.			Copper Sulphate.
		Bituminous.	Lignitic.		Ore.	Bullion and Scrap.	Bars, Sheets, Wire, etc.	
1900.....	6,847	6,242,939	67,740	620,776	16	18,970	121	3,516
1901.....	7,687	5,827,332	22,253	612,209	112	17,504	83	2,822
1902.....	9,085	5,766,377	29,601	547,406	100	18,498	149	2,839
1903.....	9,940	5,907,660	30,007	519,281	209	18,701	89	3,526
1904.....	10,854	6,190,030	30,001	548,272	1,107	22,532	89	4,506
1905.....	13,656	6,418,042	36,000	554,147	1,397	22,652	73	3,791
1906 (S)...	13,219	5,942,897	17,464	406,088	267	20,943	481	1,597
1907.....	17,961	9,692,645	23,699	677,750	44	26,181	818	3,981
1908.....	17,417	9,995,415	30,433	851,099	121	33,270	1,140	8,402
1909.....	16,185	10,482,264	38,679	701,281	13	30,606	568	4,129
1910.....	17,817	9,864,462	37,867	670,089	49	32,217	926	3,445
1911.....	22,828	10,873,799	34,381	702,707	716	37,251	538	6,598
1912.....	24,628	11,848,535	34,871	(h)915,547	765	45,460	850	16,131
1913.....	22,467	13,689,149	33,097	933,689	150	36,451	572	6,937

Year.	Copperas.	Cryolite.	Fluorspar.	Gold. (d)		Graphite.	Gypsum.		Hydrochloric Acid.
				Bullion.	Coin.		Crude.	Burned.	
1900.....	343	342	5,649	$1,111,831	$7,230,251	302	1,348	15,462	577
1901.....	269	428	5,774	13,865,103	20,353,592	318	1,405	15,830	576
1902.....	274	447	5,902	14,509,019	15,695,960	221	1,588	16,430	588
1903.....	155	521	5,445	9,825,200	9,817,283	405	1,969	18,655	603
1904.....	238	313	7,061	12,703,740	8,586,394	423	2,384	19,387	459
1905.....	169	220	7,601	1,047,792	9,204,968	735	1,553	21,286	656
1906(S)..	186	217	7,795	989,604	5,229,591	854	4,104	10,308	476
1907.....	187	613	8,779	1,106,002	5,755,918	934	5,813	11,981	629
1908.....	74	564	7,359	7,303,982	7,969,538	755	4,993	10,842	924
1909.....	56	556	8,106	36,744,037	8,631,453	660	4,907	10,410	898
1910.....	89	703	8,292	1,399,400	4,485,600	1,124	5,733	20,390	635
1911.....	66	944	9,446	3,163,554	1,902,798	1,173	6,616	16,489	612
1912.....	43	1053	6,396	667,350	1,516,911	1,834	10,585	24,944	1,115
1913.....	53	635	10,204	5,855,085	3,626,938	1,499	8,696	24,659	975

Year.	Iron.				Lead.				
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars Sheets Wire etc.	Ore.	Pig, Alloys, Crude.	Litharge.	Red and Yellow.	White.
1900.....	233,156	95,530	$4,533,599	10,313	501	7,916	141	354	106
1901.....	218,476	90,287	4,443,670	10,902	1,270	10,722	189	433	135
1902.....	197,525	43,314	4,304,818	11,584	1,879	8,706	149	428	221
1903.....	217,979	47,354	4,508,224	11,025	1,355	9,190	141	423	173
1904.....	182,515	35,091	4,976,342	9,402	1,436	7,917	146	372	138
1905.....	228,149	49,383	5,722,976	33,256	247	7,282	101	349	88
1906(f).....	232,558	57,341	6,153,698	5,085	189	11,732	82	310	75
1907.....	390,322	151,848	(g)29,520	29,268	204	12,547	98	381	126
1908.....	423,940	224,740	(g)45,235	88,396	559	17,116	161	616	201
1909.....	374,088	147,459	(g)48,344	34,025	7,560	20,697	230	599	57
1910.....	307,190	185,604	51,869	44,277	6,354	17,065	411	574	139
1911.....	469,552	112,907	53,590	32,687	1,200	17,238	299	622	108
1912.....	628,867	244,532	64,621	48,137	3,240	16,961	403	448	94
1913.....	942,312	188,324	.....	.....	8,055	12,455	402	367	113

Year.	Magnesium Chloride.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel, Old and Crude.	Nickel and Cobalt Ores	Nitric Acid.	Peat and Peat Coke.
1900.....	2,100	7,016	1,672	4,958	258	406	36	2,664
1901.....	2,529	6,367	1,595	5,109	277	788	22	2,896
1902.....	2,621	15,595	1,410	4,831	265	225	90	3,234
1903.....	3,118	38,529	1,395	4,733	268	385	7	3,097
1904.....	2,997	35,357	1,282	5,563	402	656	24	2,676
1905.....	3,495	30,483	1,467	6,018	632	391	14	2,432
1906(f)...	4,050	33,406	1,176	4,660	773	*Nil.*	12	1,918
1907.....	5,006	70,067	1,469	6,043	1,192	*Nil.*	12	4,460
1908.....	5,011	31,023	1,474	5,909	1,521	114	11	6,459
1909.....	6,095	44,970	1,357	5,773	2,116	*Nil.*	30	5,993
1910.....	6,616	59,951	1,510	7,340	1,606	*Nil.*	37	5,002
1911.....	7,171	78,790	1,494	7,157	1,598	0.1	27	5,115
1912.....	8,344	62,202	2,175	8,468	2,508	1.8	54	6,356
1913.....	7,799	67,278	2,066	6,984	1,895	.....	39	4,264

Year.	Petroleum Products.			Phosphorus and Phosphoric Acid.	Potassium Salts.			Pyrite.
	Crude Oil.	Refined Oil.	Paraffin.		Carbonate.	Chloride.	Chromate.	
1900.....	20,818	22,963	5,080	204	1,029	3,633	11	60,317
1901.....	22,545	18,067	5,294	222	1,442	4,356	21	54,202
1902.....	24,830	15,864	4,238	225	485	3,377	11	60,235
1903.....	19,710	19,382	2,598	237	197	3,727	9	73,835
1904.....	20,110	22,715	1,470	193	222	3,557	3	65,397
1905.....	18,974	24,961	888	222	154	3,864	5	86,338
1906(f).....	13,522	9,693	403	178	602	3,729	(e) 5	87,973
1907.....	18,345	11,441	524	219	174	4,807	(e)38	130,270
1908.....	3,118	9,705	358	234	324	5,009	(e)98	130,793
1909.....	1,357	9,093	508	231	314	4,782	(e)86	141,858
1910.....	18,977	16,868	457	253	185	5,052	69	153,106
1911.....	19,070	19,737	632	233	201	3,666	55	150,974
1912.....	17,874	21,153	546	258	339	5,280	55	186,690
1913.....	19,125	31,590	299	255	157	5,216	175	130,526

Year.	Quicksilver Kg.	Salt.	Sand.	Silver.		Slag and Slag Wool.	Roofing Slate.
				Bullion, Kg.	Specie.		
1900.....	1,300	39,822	77,930	29,300	$199,955	.....	13,047
1901.....	2,600	39,625	83,401	41,800	207,669	.....	11,555
1902.....	1,300	46,128	92,617	177,900	237,104	.....	14,378
1903.....	1,600	48,793	94,492	150,400	250,299	.....	11,531
1904.....	2,500	94,103	97,364	36,700	420,413	.....	9,170
1905.....	2,400	.....	104,195	36,100	143,152	.....	8,852
1906(f).....	1,800	32,182	134,526	43,000	200,754	109,827	6,020
1907.....	1,200	41,660	180,280	88,182	170,228	107,783	7,537
1908.....	2,000	54,525	177,529	96,700	101,265	115,445	7,178
1909.....	2,600	75,397	183,169	150,980	172,201	155,812	6,915
1910.....	2,300	96,936	188,762	161,600	121,000	147,192	9,019
1911.....	2,900	99,921	225,743	195,000	70,102	147,179	8,060
1912.....	3,700	113,287	249,766	91,110	78,361	204,946	7,824
1913.....	4,400	110,923	235,775	148,580	206,032	214,726	6,251

Year.	Sodium Salts.						Sulphur.
	Bi-sulphate.	Carbonate.	Carbonate (Calcined).	Hydrate.	Nitrate.	Sulphate.	
1900..	73	104	1,141	1,836	54,559	5,110	27,795
1901..	98	77	911	1,280	63,283	4,452	25,300
1902..	17	97	312	1,030	39,958	5,997	23,878
1903..	13	110	327	956	54,896	6,116	22,625
1904..	103	103	1,109	659	54,887	5,409	30,505
1905..	167	168	965	475	66,740	5,258	30,227
1906(f)	86	382	303	218	49,862	7,508	26,755
1907..	72	153	283	305	57,023	7,342	34,261
1908..	32	124	288	358	69,722	7,596	30,985
1909..	26	149	297	832	80,533	9,402	28,639
1910..	15	224	354	341	81,781	10,150	34,936
1911..	5	297	337	297	65,781	10,842	34,916
1912..	10	(i)455	260	302	92,838	14,454	40,913
1913..	12	247	262	102	93,025	12,682	39,228

Year.	Sulphuric Acid.	Tin. Ingot, Crude, Old, etc.	Whet-stones.	Zinc.			
				Calamine and Other Ores.	Spelter.	Bars, Sheets, Wires, etc.	White.
1900.....	10,643	3,439	3,643	14,181	17,844	667	875
1901.....	11,712	3,671	3,445	18,403	16,921	579	718
1902.....	12,474	3,638	3,599	20,723	17,034	651	636
1903.....	16,148	3,564	3,774	22,344	17,973	746	698
1904.....	19,878	3,528	4,272	24,039	20,787	731	840
1905.....	17,320	3,845	4,376	22,890	21,874	568	972
1906(f).....	17,020	3,320	4,377	24,014	19,467	595	347
1907.....	20,430	4,433	5,552	24,289	24,092	604	219
1908.....	25,251	4,295	5,916	19,366	26,472	1,010	361
1909.....	27,368	4,587	6,826	24,639	27,148	1,263	349
1910.....	27,421	4,674	6,915	30,880	29,168	1,898	511
1911.....	26,630	4,795	8,066	31,357	33,740	388	471
1912.....	36,714	4,806	6,826	35,376	37,558	1,260	438
1913.....	24,922	4,214	6,579	52,299	31,841	1,264	392

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes arsenious acid and sulphide. (c) Includes burned asbestos. (d) The values of gold are figured at the rate of one crown = $0.203. (e) Potassium and Sodium. (f) Last 10 months only. (g) Metric tons. (h) Not including 188,884 tons of briquettes. (i) Includes bicarbonate.

MINERAL EXPORTS OF AUSTRIA-HUNGARY. (a)
(In metric tons or dollars; 5 crowns=$1.)

Year.	Alum.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic, Metallic, Oxide, Orpiment and Realgar.	Asbestos.		Asphalt.	
			Ore.	Regulus.		Crude.	Manufactured.	Rock and Earth.	Mastic and Bitumen.
1900....	44	164	247	276	65	47	168	1,218	2,177
1901....	55	211	179	385	80	36	165	198	1,909
1902....	102	135	174	290	89	65	275	520	301
1903....	77	14	128	249	63	89	495	921	483
1904....	38	2	200	673	72	290	1,582	403	728
1905....	68	34	178	774	42	330	1,397	1,060	457
1906 (f).	68	80	314	912	66	376	1,708	2,824	799
1907....	75	81	92	698	59	351	630	3,787	771
1908....	147	92	161	527	51	442	450	1,312	1,030
1909....	65	57	97	185	117	264	561	1,800	758
1910....	346	85	54	416	9	262	604	1,545	954
1911....	157	16	77	267	13	141	992	1,845	1,218
1912....	253	7	54	689	2	530	779	1,357	1,920
1913....	454	5	.....	.....	.....	243	1,605	326	2,621

Year.	Barium.		Chloride of Lime.	Cement.	Chrome Ore.	Kaolin and Feldspar.	Coal.		Coke.
	Sulphate (b)	Chloride.					Bituminous.	Lignitic.	
1900...	23	.....	192	46,761	22	103,178	815,097	7,864,410	262,793
1901...	55	4,098	738	44,723	62	97,037	748,802	8,076,575	303,651
1902...	64	4,552	426	39,920	51	100,546	691,680	7,888,218	234,911
1903...	52	5,091	674	40,239	100	110,181	754,957	8,027,347	280,395
1904...	74	4,233	254	43,110	36	127,984	815,570	7,588,555	353,695
1905...	26	4,626	978	52,830	46	137,125	903,156	8,035,718	287,790
1906(f)	2,395	4,503	271	64,883	102	133,326	750,420	7,150,339	246,914
1907...	3,119	5,220	308	81,407	161	157,894	849,792	8,876,408	323,243
1908...	2,987	2,974	519	65,597	144	154,146	762,867	8,600,683	183,279
1909...	2,585	3,737	462	63,463	174	150,878	633,253	8,241,723	198,313
1910...	13	4,344	1,213	98,888	140	164,859	615,082	7,492,447	230,735
1911...	12	3,741	1,175	168,321	70	174,493	609,737	7,063,981	299,915
1912...	2,690	3,658	1,518	149,860	95	187,358	655,106	7,442,392	349,384
1913...	753	4,918	2,042	144,596	142	197,693	708,975	7,016,606	369,802

Year.	Fluorspar.	Copper.			Copper Sulphate.	Copperas.	Cryolite.
		Ore.	Crude and Old.	Bars, Sheets Plates, etc.			
1900.....	45	801	471	200	57	748	237
1901.....	6	1,042	435	334	23	548	231
1902.....	42	1,018	436	381	44	857	363
1903.....	12	1,308	1,226	451	45	898	521
1904.....	36	574	747	577	50	1,170	574
1905.....	5	2,328	1,253	746	49	836	638
1906.....	*Nil.*	341	1,007	816	99	861	*Nil.*
1907(f).....	*Nil.*	489	624	870	11	1,580	*Nil.*
1908.....	7	206	1,126	791	63	2,199	*Nil.*
1909.....	12	136	1,250	541	40	1,877	*Nil.*
1910.....	4	101	977	700	83	2,273	42
1911.....	0.2	126	1,309	1,109	14	2,124	122
1912.....	13	516	1,332	1,642	119	3,090	46
1913.....	15	182	1,379	1,297	172	2,653	.....

Year.	Gold.			Graphite.	Gypsum.		Hydrochloric Acid.
	Ore.	Bullion. (a)	Specie. (a)		Crude.	Calcined.	
1900	1	$120,988	$11,582,571	18,995	502	1,723	1,659
1901	0	42,427	6,880,888	14,900	461	1,206	1,632
1902	.....	22,939	13,485,087	16,771	550	1,041	791
1903	3	10,150	11,052,944	17,302	342	1,510	3,530
1904	64	5,278	9,649,605	17,430	392	1,510	3,722
1905	1,059	9,338	10,995,089	18,535	363	1,652	4,085
1906	936	88,264	8,015,967	16,871	1,970	686	2,942
1907 (f)	996	1,234,291	13,061,517	21,704	3,841	801	3,708
1908	613	70,005	11,978,828	16,535	7,241	807	3,720
1909	548	3,426,539	19,470,382	18,484	3,675	809	3,263
1910	(h)	1,750,600	10,891,800	21,191	5,110	590	4,856
1911	(h)	6,909,408	15,220,358	21,204	3,689	914	5,834
1912	573	10,952,642	21,008,500	25,246	4,113	1,174	8,461
1913	102	2,092,318	13,719,496	24,492	2,544	988	8,969

(h) Values in gold $40,200 and $38,760.

Year.	Iron.				Lime.	Magnesium Chloride and Glauber Salts.	Magnesite (Calcined).
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.			
1900	263,421	53,426	40,344	65,019	86,273	7,321	(c)
1901	229,624	26,304	46,508	28,841	82,399	7,960	40,236
1902	241,806	42,592	30,137	45,517	81,634	5,333	53,467
1903	252,520	60,237	40,807	63,031	95,644	2,360	69,058
1904	295,017	66,442	60,252	64,698	101,753	2,151	53,781
1905	373,077	63,780	63,828	69,672	94,751	1,272	92,359
1906(f)	234,924	43,694	73,575	50,247	87,468	4,094	87,765
1907	220,767	37,581	56,472	69,669	89,305	6,905	113,695
1908	220,357	17,494	32,110	29,227	62,938	2,622	87,049
1909	178,464	22,627	25,455	40,837	77,586	5,446	125,666
1910	144,827	96,114	73,473	100,541	391,989	6,332	182,911
1911	114,166	87,975	60,918	75,630	511,996	2,715	147,481
1912	111,436	50,328	48,147	49,907	583,812	2,212	171,196
1913	106,071	21,148	.....	.....	678,194	2,151	200,947

Year.	Lead.						Manganese ore.	Millstones.	Mineral Paints.	Nickel and Cobalt ores.
	Ore.	Dross.	Litharge	Metal and Alloys.	Red and Yellow.	White.				
1900	2,628	66	242	393	34	34	463	1,871	1,906	114
1901	4,143	112	179	68	32	23	398	1,971	1,947	120
1902	5,478	154	124	109	25	37	411	1,886	2,136	34
1903	8,961	147	145	152	19	25	724	2,311	1,873	12
1904	7,575	144	167	464	54	52	1,234	2,276	1,840	26
1905	7,944	342	141	957	60	39	995	2,232	2,091	16
1906(f)	4,891	223	302	602	16	52	4,170	1,753	1,367	42
1907	8,380	420	255	197	9	54	5,273	2,422	1,697	29
1908	7,107	488	312	199	22	50	2,109	3,293	2,202	Nil.
1909	5,711	294	343	306	125	80	787	3,849	2,577	Nil.
1910	6,183	322	160	418	44	510	285	3,970	3,542	13
1911	5,493	154	768	670	24	35	588	3,513	3,426	1
1912	8,618	.....	28	548	19	82	534	3,530	4,272	0.3
1913	2,828	.....	36	1,060	3	32	550	3,083	3,831	4.0

Year.	Nitric Acid.	Osokerite.	Peat and Peat Coke.	Petroleum. (d)	Benzine.	Paraffin.	Potash.	Potassium Chloride.	Pyrite.	Sulphur.
1900....	519	5,162	5,607	33,032	18,361	26	7,792	879	17,162	1,285
1901....	632	2,717	4,558	19,804	17,021	14	4,234	909	16,491	1,225
1902....	769	2,285	4,927	40,683	13,884	24	3,229	772	9,547	1,136
1903....	908	2,258	3,638	74,454	14,000	1,153	3,409	802	10,857	1,123
1904....	858	2,093	3,980	122,419	13,706	5,992	4,604	445	9,891	988
1905....	1,377	1,614	3,746	200,736	8,187	8,996	5,511	1,048	9,168	859
1906(f)	1,303	2,034	2,517	198,325	13,472	9,996	3,814	1,005	7,208	760
1907....	754	1,813	4,001	212,527	12,638	14,758	5,864	1,280	5,646	784
1908....	882	1,648	4,416	351,262	25,599	28,808	4,697	776	6,286	998
1909....	745	2,321	3,395	470,085	32,532	38,043	5,667	793	4,975	1,295
1910....	1,121	2,585	1,963	271,467	39,452	44,432	5,271	957	4,565	658
1911....	1,047	1,859	2,869	220,499	41,923	38,058	4,801	943	1,190	534
1912....	1,251	2,525	1,421	338,271	68,698	51,694	4,456	855	5,041	1,048
1913....	1,373	2,275	1,155	245,184	49,773	43,102	7,460	1,370	3,885	312

Year.	Sulphuric Acid.	Tin.			Whetstones.	Zinc.				
		Ingot and Alloys.	Bars, Plates, Sheets, etc.	Dross.		Ore.	Metallic and Alloys.	Sheets, etc.	White.	Dross.
1900...	12,693	153	102	208	2,270	20,379	1,088	502	1,719	149
1901...	10,373	162	109	257	2,359	23,150	1,374	813	2,720	167
1902...	9,451	193	128	188	2,852	24,519	2,002	1,127	3,113	237
1903...	8,369	292	111	158	2,569	15,108	4,420	729	3,446	267
1904...	9,101	126	102	123	2,159	17,314	4,606	532	3,666	158
1905...	12,823	197	94	78	2,355	19,602	5,023	498	3,861	113
1906(f)	10,493	221	62	83	1,541	15,933	4,578	323	3,504	4,285
1907...	15,190	333	84	160	1,900	19,516	4,608	585	4,873	4,873
1908...	13,581	257	49	172	2,009	19,233	6,604	880	4,131	4,131
1909...	11,232	558	82	59	1,677	19,970	7,031	867	5,078	5,078
1910...	12,016	509	58	70	2,411	22,397	8,720	303	4,968	(g)
1911...	12,111	759	77	59	1,769	16,744	710	411	4,639	(g)
1912...	16,216	(h)1,038	42	.....	1,414	14,539	(h)10,356	2,483	5,890	.....
1913...	14,902	1,061	32	.....	1,358	16,376	13,174	1,383	5,514	.....

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes artificial barium sulphate. (c) Previous to 1901, magnesite was included with other minerals not elsewhere specified. (d) From 1895 to 1898 inclusive, includes crude and refined petroleum; from 1899 to 1905 inclusive, lubricating oil is also included. (e) Where gold or silver values are reported 1 crown = $0.203. (f) Last 10 months only. (g) Not reported. (h) Includes dross.

BELGIUM

The mining and metallurgical production in Belgium, and the imports and exports, according to the latest official statistics, are as follows: Figures given in bold face are either provisional figures or estimates.

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM. (a)

(In metric tons except where otherwise noted.)

Year.	Barytes.	Chalk-marl. *Cubic Meters.*	Coal.		Coke.	Flint. *Cubic Meters.*	Iron Ore.
			Bituminous.	Briquets.		For Earthen-ware.	
1900....	38,800	3,228,205	23,462,817	1,395,910	2,434,678	25,700	247,890
1901....	22,800	1,497,250	22,213,410	1,587,800	1,847,730	17,700	218,780
1902....	33,000	1,626,670	22,877,470	1,616,520	2,102,650	17,430	166,480
1903....	21,000	1,580,330	23,796,680	1,686,415	2,428,020	16,250	184,400
1904....	60,000	1,645,655	(c)22,761,430	1,735,480	2,496,340	18,070	206,730
1905....	26,000	1,493,745	21,775,280	1,711,920	2,526,690	12,800	176,620
1906....	22,365	1,521,660	23,569,860	1,887,090	2,712,760	14,900	232,570
1907....	23,000	1,537,210	23,705,190	2,040,670	2,771,920	15,050	316,250
1908....	25,070	1,441,005	23,557,900	2,421,210	2,632,890	15,430	188,780
1909....	31,400	1,445,015	23,517,550	2,707,390	2,972,920	15,280	199,710
1910....	4,900	1,546,750	23,916,560	2,651,190	3,110,820	16,400	122,960
1911....	25,200	1,667,125	23,053,540	2,778,620	3,160,950	10,950	150,500
1912....	32,400	1,745,070	22,972,140	2,690,510	3,175,500	5,930	167,370
1913....	12,000	1,687,085	**22,845,310**	**2,608,640**	**3,447,310**	16,690	150,450

Year.	Iron, crude.					Iron and steel.			
	Foundry Pig.	Forge Pig.	Bessemer Pig.	Basic Pig.	Total Pig.	Ingots of Steel	Merchant Bars.	Beams & Special Bars.	Tires.
1900....	88,335	305,344	176,557	447,271	1,018,561	655,199	.....	.....	11,934
1901....	86,170	178,250	166,820	332,940	764,180	515,780	334,910	186,200.	12,380
1902....	104,540	254,710	199,170	510,630	1,069,050	769,040	380,990	223,380	12,790
1903....	91,600	256,890	229,160	638,430	1,216,080	969,230	446,360	138,270	17,810
1904....	99,350	224,410	217,390	742,040	1,287,597	1,065,870	543,260	268,360	23,540
1905....	98,170	206,390	220,210	784,850	1,311,120	1,200,430	570,130	299,840	25,810
1906....	96,090	218,225	177,900	870,860	1,375,775	1,440,860	552,850	346,420	32,070
1907....	92,280	189,190	88,650	1,008,170	1,406,980	1,521,610	594,170	327,930	34,700
1908....	76,290	116,740	78,950	996,870	1,270,050	1,249,620	544,810	241,060	29,000
1909....	91,040	127,080	56,430	1,340,060	1,616,370	1,580,350	628,740	291,260	33,960
1910....	82,410	115,760	55,650	1,596,970	1,852,090	1,892,160	672,730	340,850	31,860
1911....	52,970	102,690	46,240	1,836,720	2,046,280	2,128,170	711,220	380,160	35,430
1912....	94,810	66,940	44,250	2,093,480	2,301,290	2,442,420	609,930	390,340	40,220
1913....	93,830	66,370	32,260	2,291,390	2,484,690	3,104,780	855,547	213,940	175,210

Year.	Iron and Steel.				Lead.		Manganese Ore.
	Rails.	Plates.	Sheets.	Total Wrought and Steel.	Ore.	Pig.(*a*)	
1900	134,428	.....	.....	926,752	230	16,365	10,820
1901	132,260	95,190	55,300	870,230	220	61,900	8,510
1902	(*c*)268,220	101,280	67,350	1,106,950	164	73,357	14,440
1903	(*c*)351,540	113,830	74,080	1,376,630	90	68,700	6,100
1904	(*c*)266,900	126,960	79,040	1,378,750	91	(*f*)23,470	485
1905	241,640	167,240	76,510	1,469,020	126	22,885	*Nil.*
1906	274,920	166,970	84,150	1,522,995	121	23,765	120
1907	314,760	148,690	82,420	1,575,110	210	27,450	2,100
1908	(*c*)191,370	135,390	93,790	1,296,050	195	35,650	7,130
1909	214,000	170,750	112,160	1,569,560	150	40,306	6,270
1910	347,890	177,110	122,830	1,834,050	162	40,715	*Nil.*
1911	337,520	211,410	130,250	1,945,220	82	44,308	*Nil.*
1912	339,060	251,380	119,390	1,903,270	107	54,940	*Nil.*
1913	341,870	241,200	137,570	2,224,057	132	55,750	*Nil.*

Year.	Mineral Paints.	Phosphate of Lime.	Pyrite.	Slate. *Pieces.*	Silver. *Kg.*	Zinc.			
	Ochers.					Ore. (Blende)	Ore. (Calamine)	Spelter.	Sheets.
1899	(*b*) 300	(*b*)190,090	283	44,167,000	134,854	5,736	3,730	122,843	34,289
1900	(*b*) 300	(*b*)215,670	400	43,941,000	146,548	5,715	3,000	119,317	38,825
1901	2,100	222,520	560	39,030,000	169,450	4,445	2,200	127,170	37,380
1902	200	135,850	760	37,120,000	212,922	3,568	284	124,780	37,070
1903	200	184,120	720	38,953,000	232,740	3,565	65	131,740	42,280
1904	450	202,480	1,075	41,240,000	252,920	3,698	4	137,323	41,490
1905	300	193,305	976	41,435,000	201,935	3,929	*Nil.*	142,555	45,320
1906	250	152,140	908	43,801,000	173,535	3,858	*Nil.*	148,035	44,525
1907	200	181,230	397	40,102,000	178,020	3,485	5	152,370	45,330
1908	.....	198,030	357	41,180,000	228,000	2,099	3	161,940	43,410
1909	700	205,260	214	41,630,000	271,270	1,229	*Nil.*	174,490	44,850
1910	600	202,880	214	36,440,000	264,655	1,434	*Nil.*	181,745	47,970
1911	540	196,780	122	37,620,000	252,720	836	*Nil.*	198,230	48,450
1912	650	203,110	148	29,600,000	279,960	1,167	*Nil.*	205,940	49,120
1913	600	219,420	268	27,390,000	253,940	1,100	*Nil.*	204,225	51,490

(*a*) From *Statistique des Industries Extractives et Metallurgiques et des Appareils à vapeur en Belgique.*
(*b*) Cubic meters. (*c*) Includes beams. (*d*) Not including 48,595 tons imported silver lead treated.
(*e*) Net production from this year on. (*f*) Domestic lead only beginning with this year.

CANADA

The statistics of mineral production in the Dominion of Canada as reported by the Geological Survey are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (a)
(In metric tons or dollars.)

Year.	Arsenic.	Asbestos and Asbestic.	Barytes.	Cement—*Barrels.* (j)		Chromite.	Coal.	Cobalt.	Coke. (k)
				Natural Rock.	Portland.				
1900....	275	27,797	1,213	125,428	292,124	2,335	5,087,060	.....	142,521
1901....	630	36,477	592	133,328	317,066	1,274	5,648,208	.....	331,537
1902....	726	36,657	994	127,931	594,594	900	6,524,180	.....	455,353
1903....	725	37,902	1,055	92,252	627,741	3,509	6,933,107	.....	509,115
1904....	(d) 66	44,131	1,253	51,555	771,650	5,511	6,812,834	.....	493,107
1905....	*Nil.*	61,928	3,049	14,184	1,346,547	7,781	7,961,397	.....	622,154
1906....	*Nil.*	72,025	3,628	8,610	2,139,164	7,936	9,033,973	.....	(b)
1907....	317	82,117	1,829	5,775	2,368,593	6,527	9,533,442	.....	(b)
1908....	634	82,448	3,911	1,044	2,665,289	7,341	9,857,754	841	784,788
1909....	1,024	79,197	(b)	(b)	4,067,709	2,240	9,526,938	(s)	782,016
1910....	1,362	92,800	(b)	(b)	4,753,975	276	11,711,000	(s)	818,450
1911....	1,902	115,136	45	(b)	5,692,915	143	10,243,528	(s)	848,280
1912....	1,855	123,625	421	(b)	7,132,732	(b)	13,049,136	(s)	1,280,249
1913....	1,535	146,105	581	(b)	8,658,922	(b)	13,709,386	(s)	1,376,040

Year.	Copper. (In Ore, etc.)	Corundum.	Feldspar.	Gold. (c)	Graphite.	Grindstones.	Gypsum.	Iron Ore.	Iron, Pig. All kinds.
1900..	8,588	3	288	$27,908,153	1,743	5,024	228,656	110,654	87,594
1901..	17,155	403	4,852	24,128,503	2,004	4,155	266,476	284,477	248,859
1902..	17,598	697	6,871	21,336,667	993	5,835	301,165	366,431	324,617
1903..	19,357	880	12,633	18,843,590	660	5,023	285,242	239,715	270,182
1904..	19,497	834	10,057	16,400,000	410	4,091	309,133	317,387	275,367
1905..	21,596	1,492	10,617	14,486,833	491	4,693	395,341	263,113	475,491
1906..	25,863	2,063	14,397	12,023,932	405	5,029	378,904	269,842	550,628
1907..	26,025	1,716	11,414	8,264,765	525	4,881	431,286	283,820	590,444
1908..	28,895	988	7,144	9,842,105	227	3,285	309,254	215,986	572,284
1909..	23,811	1,353	11,594	9,382,230	783	3,877	429,218	(d) 243,167	(g)686,886
1910..	25,262	1,696	14,114	10,205,835	1,263	3,604	476,496	(d) 235,342	(g)726,471
1911..	25,250	1,336	16,074	9,781,077	1,151	4,818	458,550	190,823	832,376
1912..	35,314	1,778	12,456	12,648,794	1,869	4,002	524,661	107,143	920,229
1913..	34,926	1,069	14,453	16,216,131	1,961	3,886	580,206	196,469	1,023,973

Year.	Iron and Steel, Rolled.	Lead. (In ore, etc.)	Manganese Ore.	Mica.	Mineral Paints. (Ochers.)	Natural Gas.	Nickel. (In ore, etc.)	Petroleum, Crude. *Barrels.* (e)
1900....	102,301	28,648	27	166,000	1,783	$417,094	3,211	710,498
1901....	113,799	23,537	(d)399	160,000	2,025	339,476	4,167	623,392
1902....	164,069	10,411	(d)156	135,904	4,494	195,992	4,849	530,624
1903....	131,588	8,226	83	177,857	5,683	202,210	5,671	496,637
1904....	(b)	17,241	(d)112	152,919	3,562	247,370	4,786	552,575
1905....	(b)	25,391	(d) 20	168,170	4,632	314,249	8,565	634,095
1906....	(b)	24,580	(d) 84	(d)581,043	6,201	528,868	9,745	569,753
1907....	(b)	21,570	.....	333,022	7,115	748,541	9,610	788,872
1908....	(h)534,117	19,593	.....	139,871	4,305	1,012,660	8,685	527,987
1909....	(h)684,670	20,801	.....	147,782	3,573	1,207,029	11,922	420,755
1910....	(h) 45,932	14,963	.....	190,385	4,365	1,346,471	16,905	315,895
1911....	(h) 00,7[illegible]	10,617	5	128,667	3,285	1,917,673	15,457	291,092
1912....	868,617	16,227	68	143,976	6,942	2,362,700	20,346	243,336
1913....	.....	17,089	.....	170,112	5,430	3,338,314	22,539	228,060

Year.	Phosphate (Apatite).	Pyrites.	Salt.	Silver—*Kg.* (In ore, etc.)	Soapstone and Talc.
1900	1,283	36,308	56,284	138,980	1,288
1901	937	31,982	53,901	172,292	235
1902	776	32,304	58,462	133,478	625
1903	1,205	30,822	56,644	99,489	898
1904	832	29,980	62,411	115,666	762
1905	1,180	29,713	41,159	185,839	454
1906	(*b*)	35,927	69,283	266,521	1,119
1907	680	35,494	65,936	390,359	1,391
1908	1,447	42,934	72,537	687,504	976
1909	905	58,645	76,237	856,263	3,945
1910	1,341	48,871	76,286	1,022,350	6,450
1911	563	74,978	83,065	1,012,586	6,621
1912	149	73,944	86,210	993,818	7,501
1913	.....	207,532	91,417	987,444	11,111

(*a*) From *Reports Compiled by the Geological Survey of Canada.* (*b*) Not reported. (*c*) Gold values are calculated at the rate of $20.67 per oz. (*d*) Export. (*e*) One barrel contains 35 imp. gal. (*g*) From Canadian ore, 149,444 short tons in 1909, 104,906 tons in 1910, 42,186 tons in 1911, and 36,355 tons in 1912, 66,672 tons in 1913. (*h*) Steel ingots and castings. (*i*) 1909, $94,609; 1910, $51,986; 1911, $221,790; $319,785 in 1912, $689,511 in 1913 for oxides of cobalt and nickel; values received. (*j*) Bbl. of 350 lb. each, sold or shipped. (*k*) Including that from foreign coal.

MINERAL IMPORTS OF THE DOMINION OF CANADA. (*a*)

(In metric tons or dollars.)

Year. (*b*)	Aluminium.		Antimony. (*c*)	Arsenic.	Asbestos. (*d*)	Asphalt.	Cement.
	Manufactures. (*m*)	Ingots, Sheets, etc.					
1901	$16,202	.....	159	72	$50,829	2,849	$666,350
1902	30,496	.....	229	48	52,464	3,426	863,646
1903	14,201	$ 13,930	393	135	75,465	3,037	890,745
1904	16,065	101,427	190	188	83,827	7,093	1,014,713
1905	28,418	154,569	85	122	116,836	5,096	1,263,828
1906	23,565	168,405	183	202	138,000	7,178	1,003,022
1907(*o*)	20,656	218,399	146	158	127,509	11,929	540,006
1908(*r*)	37,197	131,762	220	228	191,204	14,113	865,275
1909(*r*)	30,076	167,019	201	58	181,710	15,979	473,211
1910(*r*)	42,493	424,006	232	12	198,756	19,661	159,040
1911 (*r*)	83,638	782,254	257	115	254,331	23,248	(*t*)494,446
1912(*r*)	119,070	487,490	233	159	349,655	28,291	(*t*)936,425
1913(*r*)	126,531	403,700	400	259	497,160	47,353	(*t*)1,955,177
1914(*r*)	145,762	730,012	322	127	474,499	48,541	352,134

Year.	Coal.		Coke.	Copper.	Copper, Sulphate.	Gold and silver.
	Anthracite. (*f*)	Bituminous. (*f*)		Ingots, Pig and Scrap.		Coin and Bullion. (*g*)
1901	1,753,488	2,658,257	280,069	432	673	$3,537,294
1902	1,498,773	3,208,005	242,298	801	711	6,311,405
1903	1,320,239	3,684,502	232,848	924	1,010	8,976,797
1904	2,064,444	4,230,436	200,590	960	795	7,874,313
1905	2,361,952	4,377,667	337,035	882	934	10,308,435
1906	1,996,183	5,003,029	435,561	1,191	844	7,078,603
1907(*o*)	1,260,723	4,022,843	363,286	1,186	897	7,029,047
1908(*r*)	2,803,681	7,681,464	561,677	1,638	1,161	6,548,661
1909(*r*)	2,775,680	6,526,797	423,013	1,239	963	9,988,442
1910(*r*)	2,860,196	10,382,156	636,888	2,329	859	6,017,589
1911(*r*)	3,144,130	7,785,259	692,292	2,279	772	10,206,210
1912(*r*)	3,736,169	9,526,138	582,331	2,514	930	26,033,881
1913(*r*)	3,844,062	10,034,383	644,207	2,581	1,153	5,527,979
1914(*r*)	3,977,919	12,474,099	642,861	2,511	606	15,235,305

Year.	Graphite.		Gypsum.		Iron and Steel.		
	Crude.	Manufactures. (h)	Crude and Ground.	Plaster of Paris.	Pig and Scrap.	Slabs, Blooms Bars, etc.	Alloys of Iron.
1902.....	$3,649	$64,123	516	215	71,882	18,208	5,910
1903.....	2,870	69,676	1,007	286	129,641	17,896	5,762
1904.....	1,802	67,563	626	291	86,067	9,088	2,700
1905.....	2,499	75,288	2,972	3,595	90,698	14,420	11,738
1906.....	2,791	86,028	5,743	6,579	112,937	29,520	13,628
1907(o).....	3,176	57,430	8,334	9,730	137,654	17,369	17,785
1908(r).....	3,030	78,380	8,519	6,955	190,994	35,534	16,139
1909(r).....	1,408	75,608	9,359	7,712	62,967	43,263	13,571
1910(r).....	5,223	95,900	3,618	19,095	159,515	97,036	14,471
1911(r).....	4,300	97,057	11,443	19,664	266,269	139,060	15,773
1912(r).....	6,163	84,240	2,130	9,313	214,046	80,250	16,578
1913(r).....	6,105	89,719	8,800	28,975	306,927	77,176	20,837
1914(r).....	3,639	71,340	2,441	15,077	216,325	145,661	26,153

Year.	Kainite.	Lead.				Lime.		Mineral Paints (Ochers).
		Pig and Scrap.	Bars and Sheets.	Litharge.	Pigments and Zinc White.	Burned. *Barrels.*	Chloride of.	
1902...	85	(i)5,548	844	590	7,071	24,602	1,806	1,148
1903...	259	(i)4,471	523	632	8,715	31,108	2,104	1,459
1904...	339	4,292	.....	.....	7,679	54,359	2,080	1,256
1905...	306	2,589	800	811	9,695	98,676	2,507	1,417
1906...	306	3,751	730	461	6,947	134,334	2,645	809
1907(o)	511	3,811	622	513	2,215	88,919	2,302	570
1908(r)	743	2,902	782	864	5,743	129,379	3,421	788
1909(r)	562	2,273	623	550	3,998	153,934	2,697	546
1910(r)	687	5,755	580	915	4,433	191,527	4,554	914
1911(r)	339	5,292	707	750	5,312	176,730	4,745	1,169
1912(r)	262	10,934	1,356	745	4,921	230,013	5,584	1,358
1913(r)	19	10,980	918	1,197	6,627	360,242	5,248	1,649
1914(r)	190	4,945	654	512	6,821	.....	6,260	2,331

Year.	Nickel.	Petroleum Products.		Platinum.	Potassium Salts.		Quicksilver.
		Illuminating Oil etc., Crude or Refined. *Gallons.*	Paraffin Wax and Candles.		Except Saltpeter.	Saltpeter.	
1902.....	$15,448	13,220,005	123	$19,357	771	690	44
1903.....	26,177	18,799,312	307	21,251	1,060	916	75
1904.....	14,682	24,521,115	228	28,112	1,151	898	69
1905.....	19,076	13,229,855	98	61,719	945	1,048	47
1906.....	15,976	10,981,611	375	54,494	1,317	1,141	68
1907(o).....	19,461	8,066,403	189	113,967	1,074	638	44
1908(r).....	.....	8,844,129	102	63,582	3,396	2,653	81
1909(r).....	(e)67,107	13,095,593	103	47,371	1,570	925	42
1910(r).....	(e)98,238	(u)48,384,763	253	80,180	2,497	665	129
1911(r).....	137,114	(u)66,119,105	931	136,823	3,152	1,490	89
1912(r).....	135,227	88,916,283	808	190,770	3,734	1,049	49
1913(r).....	194,079	164,013,894	892	221,300	5,643	835	67
1914(r).....	144,343	202,539,120	570	130,485	7,840	776	115

Year.	Sal-Ammoniac.	Salt.	Silex.	Sodium Salts Except Chloride.	Sulphur.	Tin and Tin-ware.	Zinc.
1902...	78	114,629	199	17,133	11,180	$2,293,958	1,582
1903...	114	112,188	159	18,887	11,077	2,712,168	1,209
1904...	93	103,635	252	25,118	8,786	2,389,557	1,540
1905...	143	97,723	405	26,219	10,633	2,791,757	1,721
1906...	209	99,788	338	30,401	19,512	3,105,876	3,383
1907(o).	130	73,156	542	25,068	11,725	2,473,572	2,761
1908(r).	172	105,286	1,131	39,154	23,494	1,619,647	2,521
1909(r).	162	119,660	417	33,787	19,981	2,984,065	2,993
1910(r).	303	121,473	582	47,913	19,484	3,512,615	(v)7,606
1911(r).	346	111,174	468	62,969	22,935	4,235,848	(v)6,069
1912(r).	377	119,114	337	74,016	20,430	3,710,102	7,217
1913(r).	544	100,494	658	98,561	32,984	3,055,943	9,397
1914(r).	356	132,713	755	100.701	27,093	5,691,024	7,398

EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (a)
(In metric tons or dollars.)

Year (b).	Antimony Ore.	Asbestos.	Chromite.	Coal.	Coke.	Copper (s).
1902.....	13	30,011	(k) 672	1,649,278	52,873	13,789
1903.....	128	27,823	658	1,796,689	39,616	13,445
1904.....	87	31,444	2,103	1,494,106	61,750	20,279
1905.....	340	37,320	3,702	1,465,809	116,387	17,431
1906.....	388	40,367	1,640	1,651,203	50,004	20,082
1907(o).....	832	37,194	604	1,165,809	44,669	11,845
1908(r).....	693	53,543	1,585	1,702,673	50,343	25,824
1909(r).....	1	54,188	3,707	1,548,468	70,024	24,642
1910(r).....	33	58,083	1,052	1,822,398	44,343	26,107
1911(r).....	222	63,348	14	2,100,309	54,380	24,950
1912(r).....	1	69,233	.....	1,436,798	13,677	25,595
1913(r).....	.....	83,299	.....	1,920,809	56,271	36,717
1914(r).....	.....	96,116	.....	1,359,430	66,482	37,500

Year.	Gold. Quarts, Dust, etc.	Graphite.	Grindstones.	Gypsum crude.	Iron ore.	Lead (p).
1902.....	$19,668,015	783	$21,878	243,629	(n)478,503	13,890
1903.....	16,437,528	530	14,169	271,899	(n)267,000	7,386
1904.....	18,715,539	269	12,676	247,741	(n)214,309	7,329
1905.....	15,208,380	201	27,985	290,574	204,091	23,094
1906.....	12,991,916	180	15,793	367,203	134,270	6,158
1907(o)...	7,226,954	3	33,929	249,780	31,011	8,330
1908(r)...	8,817,041	167	28,726	340,235	23,863	12,650
1909(r)...	7,392,610	396	18,019	239,139	3,568	5,459
1910(r)...	6,110,473	1,164	13,754	304,736	28,608	8,395
1911(r)...	5,344,465	362	23,914	325,928	95,080	1,451
1912(r)...	7,211,438	1,395	30,513	324,324	34,162	52
1913(r)...	11,231,476	1,572	27,375	344,183	123,004	93
1914(r)...	13,326,755	1,367	54,584	343,293	103,081	125

Year.	Manganese Ore.	Mica.	Nickel in Ore, Matte, etc.	Petroleum, Crude and Refined.	Pyrites.	Salt. *Bushels.*	Silver, *Kg.* (in ore, matte, etc).
1902	500	452	1,762	2,478	24,088	21,778	114,610
1903	137	632	4,098	413	16,762	7,959	100,861
1904	62	393	6,456	1,208	15,582	42,662	99,472
1905	84	461	5,431	6,441	20,473	5,663	112,076
1906	15	603	10,866	1,741	18,398	23,168	203,323
1907(o)...	84	631	7,355	(q)3,167	20,148	5,113	274,178
1908(r)...	1	409	8,596	(q)3,389	17,835	35,543	515,161
1909(r)...	3	243	8,895	(q)195	23,087	(w)3,040	733,248
1910(r)...	5	397	13,891	(q)9,093	24,439	(w)6,088	932,098
1911(r)...	2	370	15,771	(q)1,493	32,396	(w)6,625	1,049,153
1912(r)...	12	348	15,073	38,663	25,279	109,963	960,586
1913(r)...	7	415	21,849	152,746	3,109	60,536	1,096,835
1914(r)...	.....	321	22,949	(q)25,443	41,988	6,165	1,144,182

(a)From Tables of the *Trade and Navigation of the Dominion of Canada.* (b) Fiscal year endign June 30. (c) Includes regulus and salts of antimony. (d) Asbestos in any form except crude, and all manufactures of. (e) Includes copper in ore, matte, regulus, etc. (f) Includes coal dust. (g) Coin, gold and silver, except U. S. silver coin. (h) Includes black lead and crucibles (clay or graphite). (i) Includes Canadian lead ore refined in the United States. (k) Calendar year. (m) Unclassified. (n) Includes chromic iron ore. (o) Returns for the 9 months of the fiscal year ending March 31. (p) Includes lead contained in ore, etc. (q) Gallons. (r) Fiscal year ending March 31. (s) Includes silver-nickel and German silver. (t) Weight, 64,176 tons; 46,821 and 247,940 net tons. (u) Includes all oils. (v) Not including manufactures. (w) Using 60 lbs. per bushel.

CHINA

The official statistics of mineral imports and exports are summarized in the following table: Figures given in bold face are either provisional figures or estimates.

MINERAL IMPORTS OF CHINA. (a)

(In metric tons.)

Year.	Brass and Yellow Alloys.	Copper.	Lead.	Nickel.	Petroleum, Gal.	Quicksilver.	Tin.	Tinplate.	Zinc.	
									Spelter.	Sheet, etc.
1909 (c)	1,516	1,012	8,198	127	145,719,886	40	3,076	11,774	113	727
1910...	1,674	2,428	9,247	134	161,399,583	51	2,684	11,569	.....	858
1911...	1,244	4,406	8,138	39	235,898,240	49	1,994	21,676	81	769
1912...	970	7,368	6,187	56	197,902,362	49	2,548	21,036	443	861

MINERAL EXPORTS OF CHINA. (a)

(In metric tons.)

Year.	Antimony.		Iron.		Lead.		Quicksilver.	Tin.	Zinc.	
	Ore.	Metal(b)	Ore.	Pig and Mnfd.	Ore.	Pig.			Ore.	Spelter.
1909.....	776	7,937	89,100	38,714	4,039	12	51	4,516	7,578	242
1910.....	5,762	6,643	132,561	65,381	5,176	3	48.5	6,510	9,786	328
1911.....	6,812	6,986	112,295	70,906	5,410	11.2	18.5	6,056	4,599	710
1912.....	2,054	13,531	355,538	12,604	4,276	20	4.3	8,786	7,170	760

(a) From annual reports of the Imperial Chinese Maritime Customs. (b) Regulus and refined. (c) Reported jointly by U. S. Consuls at Hongkong and Tientsin. (d) Through Consul General Anderson, Hongkong, figures directly from the Inspectorate General of Customs at Shanghai.

FRANCE

In the following tables are given the statistics of mineral and metal production in France and the French colonies—Algeria, New Caledonia and Tunis—together with the foreign commerce of France in mineral and metal products: Figures given in bold face are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE. (a)
(In metric tons.)

Year.	Aluminium.	Antimony.		Arsenic Ore.	Asphaltum.	Barytes.	Bauxite.	Bitumen. (c)	Cement.
		Ore.	Metal.						
1900.....	1,026	7,843	1,573	4,705	25,228	3,635	58,530	266,474	1,147,670
1901.....	1,200	9,867	1,786	7,491	20,391	4,145	76,620	249,655	1,127,206
1902.....	1,355	9,715	1,725	5,372	.....	4,323	96,900	258,295	**962,930**
1903.....	1,570	12,380	2,748	6,658	.....	5,731	133,890	243,295	**898,393**
1904.....	1,650	9,065	2,116	3,117	22,000	6,944	75,640	227,177	**903,622**
1905.....	1,905	12,543	2,396	3,627	20,000	5,504	103,207	188,403	922,531
1906.....	3,396	18,567	3,433	6,534	38,231	11,680	117,781	196,375	1,257,861
1907.....	4,700	24,000	3,950	7,900	33,000	11,150	158,000	177,000	1,253,546
1908.....	4,681	26,026	3,850	2,381	41,000	16,277	170,679	171,158	1,359,658
1909.....	6,092	28,105	5,444	2,141	44,800	14,111	130,149	169,000	1,374,574
1910.....	6,425	28,130	4,640	8,045	38,500	11,632	196,056	169,769	1,521,131
1911.....	7,400	29,267	4,775	19,000	39,000	10,064	4,831	170,000	1,795,000
1912.....	10,200	11,018	(b)5,406	81,880	31,535	13,620	258,929	280,313	1,924,277

Year.	Coal.	Lignite.	Peat.	Copper.		Gold.	Gypsum.	
				Ore.	Metal.		Crude.	Calcined.
1901.....	31,633,300	691,700	118,433	3,413	7,000	$85,727	355,995	1,623,710
1902.....	29,365,047	632,423	109,941	828	6,300	(b)	219,487	1,572,687
1903.....	34,217,661	688,757	100,348	10,892	6,921	(b)	162,766	1,468,830
1904.....	33,502,394	665,572	95,716	2,756	6,900	(b)	106,173	1,481,303
1905.....	35,218,000	709,000	98,500	5,068	7,576	235,447	78,832	1,299,313
1906.....	33,458,000	738,000	92,469	2,547	5,770	511,665	79,568	1,297,861
1907.....	35,989,000	765,000	90,952	2,400	7,800	847,290	87,370	1,316,567
1908.....	36,633,000	751,000	79,759	766	7,935	960,666	92,898	1,326,131
1909.....	37,115,500	724,500	78,600	458	7,823	1,147,400	76,057	1,263,692
1910.....	37,634,893	715,000	48,415	222	12,933	(h) 1,706,580	64,181	1,533,298
1911.....	38,521,000	709,000	58,521	35	13,200	(h) 1,463,519	59,648	1,640,698
1912.....	40,394,000	751,000	42,710	242	11,907	**1,993,620**	25,900	1,700,000

Year.	Iron.				Lead.		Lime.	Manganese Ore.	Millstones.
	Ore.	Pig.	Wrought. Iron.	Wrought. Steel.	Ore. (d)	Pig. (e)			
1901.	4,260,747	2,388,823	612,362	1,175,454	20,644	21,000	2,443,062	22,304	33,286
1902.	5,003,782	2,405,000	639,600	1,245,800	22,634	19,000	4,796,807	12,536	34,504
1903.	6,219,541	2,840,517	598,910	1,305,709	23,080	23,258	4,727,543	11,583	35,031
1904.	7,022,841	2,999,787	554,632	1,482,708	14,173	18,800	4,583,522	11,254	37,409
1905.	7,395,409	3,077,000	670,000	1,442,000	12,118	24,100	3,694,725	6,751	33,468
1906.	8,481,423	3,314,100	747,900	1,683,500	11,795	25,614	3,869,772	11,189	33,407
1907.	10,008,000	3,590,000	579,900	1,860,000	18,000	24,800	2,438,409	18,200	30,480
1908.	10,057,145	3,400,700	560,200	1,851,900	13,403	26,112	2,535,833	15,865	30,522
1909.	11,890,000	3,573,848	558,000	2,040,364	13,794	26,927	2,211,653	9,378	30,503
1910.	14,605,542	4,038,000	526,000	2,324,000	14,536	20,226	2,110,540	7,925	32,461
1911.	16,639,000	4,470,100	518,000	3,812,665	14,098	23,635	3,291,000	6,036	34,255
1912.	19,160,000	4,949,126	525,000	4,403,688	13,953	31,080	3,807,596	5,576	33,751

Year.	Mineral Paints (Ochers).	Nickel.	Phosphate Rock.	Pyrites.	Salt.	Silver. Kg.	Sulphur. Ore. (g)	Zinc.	
								Ore.	Metal.
1900....	33,080	1,700	587,919	305,073	1,088,634	.....	11,551	67,059	36,305
1901....	35,704	1,800	535,676	307,447	910,000	.....	7,000	61,539	37,600
1902....	34,770	1,600	543,900	318,235	863,927	.....	8,021	57,982	36,300
1903....	34,042	1,500	475,783	322,118	967,531	.....	7,375	66,922	37,416
1904....	34,945	1,500	423,521	271,544	1,153,754	.....	5,447	52,842	41,600
1905....	37,800	1,800	476,720	267,114	1,162,100	.....	4,637	62,150	43,200
1906....	35,550	1,750	469,408	265,261	1,388,500	50,058	2,713	53,466	46,536
1907....	32,856	1,500	432,237	283,000	1,324,000	47,009	2,000	44,000	47,900
1908....	33,060	1,800	485,607	284,717	1,173,000	61,184	2,189	52,611	47,880
1909....	33,540	1,600	397,908	273,221	1,113,000	63,671	2,900	96,903	49,956
1910....	32,870	2,100	333,506	250,432	1,051,427	52,957	2,641	50,624	52,598
1911....	34,542	1,180	312,204	277,900	1,339,000	47,277	1,200	43,761	57,110
1912....	41,810	1,725	313,151	282,202	1,098,525	63,736	1,018	45,700	62,650

(a) From *Statistique de l'Industrie Minérale.* (b) Not reported. (c) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (d) Argentiferous lead ore. (e) Lead produced from native ores only. (g) Sulphur and limestone impregnated with sulphur. (h) From ores. (i) Regulus and oxide.

MINERAL PRODUCTION OF ALGERIA. (a)

(In metric tons.)

Year.	Antimony Ore.	Copper Ore.	Gypsum.		Iron Ore.	Lead-Silver. Ore.	Mercury.	Onyx.	Phosphate Rock.	Salt.	Zinc Ore.
			Crude.	Plaster.							
1900...	93	.....	500	37,100	174,000	222	.....	228	319,422	18,325	30,281
1901...	....	7,267	600	34,740	161,303	1,614	.....	294	265,000	18,518	26,913
1902...	39	1,955	600	35,500	525,012	26	.....	150	305,174	27,263	33,139
1903...	490	100	300	33,000	588,893	499	.....	67	320,834	26,329	43,313
1904...	160	1,804	350	38,420	468,737	511	.....	121	343,317	18,563	47,192
1905...	.....	1,784	.....	34,743	568,609	7,470	.....	270	334,784	26,986	67,922
1906...	50	2,786	.....	27,950	779,826	11,246	.....	216	333,531	22,615	74,351
1907...	799	16,259	.....	26,400	973,445	15,264	590	328	373,763	20,390	71,046
1908...	190	3,330	.....	25,500	943,424	10,626	1,556	300	452,060	25,215	94,398
1909...	163	67	.....	29,000	836,044	11,131	.....	200	345,385	17,817	81,852
1910 (a)	(c)4475	112	.....	48,500	1,064,909	12,652	50	123	412,319	21,470	94,445
1911...	(c)7428	4,939	.....	51,760	1,025,643	17,909	.....	198	335,059	20,431	60,895
1912...	(c)2165	316	.....	.....	1,225,625	24,516	.....	300	373,881	23,950	84,495
1913...	(c) 497	2,299	.....	.....	1,356,061	30,510	10	....	438,601	.....	82,085

MINERAL PRODUCTION OF NEW CALEDONIA. (a)

(In metric tons.)

Year.	Chrome Iron. Ore.	Cobalt. Ore.	Copper Ore.	Nickel. Ore.	Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1900.....	10,474	2,438	2	100,319	1907...	57,367	29,800	437	119,000
1901.....	17,451	3,123	6,349	132,814	1908...	25,371	2,360	(b) 10	108,000
1902.....	10,281	7,512	3,720	129,653	1909...	40,000	548	9,600	86,000
1903.....	21,437	8,292	10	77,360	1910...	40,000	54	8,000	99,000
1904.....	42,197	8,964	*Nil.*	98,655	1911...	35,000	*Nil.*	1,900	142,000
1905.....	51,374	7,920	*Nil.*	125,289	1912(c)	51,516	*Nil.*	(d)	74,312
1906	84,211	2,600	207	118,890	1913(c)	63,370	.....	.....	93,190

(a) From *Statistique de l'Industrie Minérale.* (b) From *Le Bulletin du Commerce* Nouméa. (c) Exports *Echo des Mines.* (d) Copper matte worth $101,000.

MINERAL PRODUCTION OF TUNIS. (a)

(In metric tons.)

Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.	Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.
1901....	16,900	8,158	172,000	17,879	1908...	149,600	37,500	1,300,500	26,500
1902....	12,600	12,892	264,930	18,400	1909...	118,400	41,600	1,300,000	24,500
1903....	18,846	12,752	352,088	21,262	1910...	199,700	(c)37,000	1,334,000	(c)32,500
1904....	23,600	16,800	455,197	27,200	1911...	63,700	36,100	1,592,000	(c)27,900
1905....	54,900	15,200	522,000	37,100	1912...	92,000	51,300	2,050,000	37,400
1906 ...	62,600	14,800	796,000	32,400	1913(c)	.....	62,818	1,984,880	33,294
1907 ...	78,200	18,600	1,069,000	22,800					

(a) From *Statistique de l'Industrie Minérale.* (b) Not reported. (c) From *l'Echo des Mines.*

MINERAL IMPORTS OF FRANCE. (a) (k)

(In metric tons or dollars. 5 f = $1.)

Year.	Alum.	Bitumen. (f)	Borax.	Bromides.	Cement.	Coal and coke.	Copper.		Copper.	
							Ore.	Ingot and Mfres.	Sulphate.	Oxide.
1898....	27	20,385	139	30	11,290	10,445,090	8,779	52,976	30,897	52
1899....	34	30,770	123	46	13,640	11,896,030	8,517	58,419	21,733	36
1900....	23	39,598	111	10	13,612	14,601,981	9,766	61,638	22,820	84
1901....	39	28,888	128	3	16,232	13,925,623	13,383	47,035	15,313	162
1902....	36	26,053	141	3	15,720	13,137,720	17,862	54,484	22,273	111
1903....	138	27,573	312	9	21,152	14,029,687	9,796	59,126	25,428	129
1904....	370	17,178	3,113	17	21,702	13,936,475	9,942	69,183	30,856	142
1905....	63	24,606	1,736	31	21,954	13,910,523	14,252	70,101	23,805	57
1906....	105	99,336	189	93	24,974	17,848,284	11,932	64,590	15,358	97
1907....	.....	31,700	.....	.....	24,839	18,706,000	12,063	76,282	.....	.....
1908....	.....	48,000	.....	.....	31,550	18,563,000	15,300	86,985	.....	.....
1909....	.....	54,000	.....	.....	46,664	19,387,000	27,400	86,143	.....	.....
1910....	46	36,360	8,322	17	51,905	18,145,872	23,362	93,548	11,887	427
1911....	129	32,207	3,128	12	86,457	19,740,539	24,585	104,724	17,759	151
1912....	190	39,508	3,277	20	115,286	19,878,477	19,671	112,148	16,800	134
1913....	.....	.....	.....	.....	.....	.....	9,653	.....	.....	.....

Year.	Cobalt Ore.	Iron.					Kaolin.	Lead.		
		Ore.	Pig.	Iron and Steel, Mfres. of.	Sulphate.	Oxide.		Ore.	Carbonate.	Pig, Scrap and Mfres.
1898....	.....	2,032,240	(b)	47,325	896	1,021	40,352	14,377	1,376	74,902
1899....	.....	1,950,665	(b)	64,178	1,698	1,037	36,904	12,637	2,029	67,149
1900....	.....	2,119,003	149,755	118,152	1,589	1,022	39,842	19,772	1,739	70,857
1901....	.....	1,662,875	61,085	77,742	45	1,001	41,972	15,430	1,789	59,051
1902....	.....	1,563,334	38,521	60,697	17	1,051	41,165	13,121	2,223	58,694
1903....	.....	1,832,820	121,726	119,799	36	1,207	47,534	20,172	2,040	75,416
1904....	.....	1,738,514	135,252	125,709	319	1,151	50,465	25,731	2,221	76,198
1905....	.....	2,151,954	122,102	150,480	709	1,330	52,603	35,103	2,306	73,938
1906....	.....	2,015,550	156,618	342,411	132	1,311	44,772	43,137	2,072	67,651
1907....	1,396	1,999,000	154,031	336,337	.....	.....	53,447	42,342	.....	53,359
1908....	1,500	1,454,000	168,810	373,624	.....	.....	58,909	40,700	.....	70,824
1909....	400	1,202,619	194,225	354,428	.....	.....	59,490	38,400	.....	68,332
1910....	2.6	1,318,520	36,637	378,227	2,243	1,235	62,920	28,950	3,259	64,517
1911....	0.3	1,350,794	49,612	77,000	4,454	1,511	66,500	47,340	3,095	69,791
1912....	.....	1,454,190	57,241	114,100	2,800	1,466	63,783	42,499	2,919	65,449
1913....	.....	.....	.....	.....	.....	.....	61,255	39,772	.....	.....

Year.	Lime, Chloride of.	Manganese Ore.	Nickel.		Petroleum.	Phosphate Rock.	Platinum *Kg.*	Potassium.	
			Ore.	Metal.				Chloride.	Chromate. (*h*)
1898....	1,288	100,243	24,935	330	291,961	336,842	505	10,929	2,890
1899....	1,887	106,630	28,620	286	306,078	242,021	817	13,335	3,147
1900....	1,215	120,790	17,687	299	302,482	283,921	2,398	13,524	3,293
1901....	1,400	94,365	39,497	252	225,962	275,285	1,857	13,299	2,784
1902....	2,130	85,629	58,374	301	148,170	302,898	2,940	10,802	2,861
1903....	919	109,930	13,933	427	(*g*)476,230	343,012	3,764	12,275	2,760
1904....	1,679	105,652	20,698	313	(*g*)435,730	419,720	5,650	14,734	2,618
1905....	406	140,871	49,698	632	(*g*)512,727	447,738	4,023	21,819	2,619
1906....	593	127,235	44,960	480	(*g*)213,462	533,213	5,708	26,523	3,024
1907....	.....	192,448	45,892	979	(*g*)311,000	636,549	4,373	.....	.....
1908(*k*)..	.....	170,500	42,200	1,281	(*g*)300,000	767,424	3,955	.....	.....
1909(*k*)..	.....	177,314	12,200	.....	(*g*)300,000	645,178	5,914	.....	.....
1910....	333	188,292	28,001	2,074	(*g*)271,500	687,675	7,795	34,974	3,009
1911....	53	235,400	43,014	6,465	(*g*)375,000	740,375	9,392	39,508	2,991
1912....	24	225,379	27,126	5,032	(*g*)360,000	903,490	6,236	45,174	3,178
1913....	.....	258,929	10,292	.....	.....	934,679	.....	.....	.....

Year.	Potassium (*Cont'd*).		Pyrite.	Quicksilver.		Sal-ammoniac.	Salt.	Sodium.	
	Nitrate.	Carbonate		Ore.	Metal.			Hydrate.	Nitrate.
1899....	1,015	2,779	109,696	21	276	12,210	37,970	1,494	9,341,600
1900....	1,928	2,768	156,825	22	161	15,205	32,045	1,062	11,995,820
1901....	757	2,520	205,617	23	205	9,268	32,347	869	10,526,400
1902....	1,547	1,539	170,783	24	224	15,446	32,505	643	9,372,600
1903....	1,530	3,019	205,322	20	220	12,462	48,556	781	10,810,775
1904....	2,117	3,781	230,097	22	208	13,744	46,232	1,068	9,074,859
1905....	1,022	3,542	271,684	.....	228	11,639	45,241	860	11,336,752
1906....	684	2,206	349,514	.....	242	18,146	38,361	614	13,678,848
1907....	.....	.....	355,300	.....	216	.....	30,000	.....	.....
1908(*k*) .	.....	.....	348,300	.....	180	.....	33,000	.....	.....
1909(*k*) .	.....	.....	275,600	.....	191	.....	30,000	.....	.....
1910....	132	2,579	309,400	.....	146	27,860	49,800	577	345,160
1911....	174	4,452	318,530	.....	196	23,200	47,200	550	317,725
1912....	53	4,017	486,072	.....	213	25,056	39,500	556	354,776
1913....	.....	.....	186,348	.....	.....	.....	.....	.....	322,115

Year.	Sulphur.	Sulphuric Acid.	Superphosphate of Lime.	Tin.		Zinc.	
				Ore.	Metal.	Ore.	Metal.
1899.....	120,062	4,583	171,631	486	6,907	78,192	25,516
1900.....	133,531	4,254	143,437	512	7,324	66,178	33,144
1901.....	101,301	5,386	165,361	365	7,314	74,553	29,812
1902.....	85,339	7,793	116,093	748	8,575	69,451	36,564
1903.....	109,594	13,241	89,229	1,808	9,873	67,258	39,305
1904.....	148,547	11,212	72,921	1,344	9,352	88,083	35,737
1905.....	129,877	10,915	31,729	1,362	9,898	105,069	29,163
1906.....	131,678	5,268	44,502	1,038	7,687	106,307	26,960
1907.....	106,050	.....	.....	961	7,693	114,699	33,503
1908(*k*).....	195,000	.....	.....	1,000	8,482	137,900	40,312
1909(*k*).....	196,300	.....	.....	1,900	9,683	120,600	32,749
1910.....	202,263	14,642	132,530	1,651	8,517	193,360	19,237
1911.....	267,969	15,150	79,385	2,544	8,456	160,180	42,785
1912.....	172,181	13,169	89,059	1,726	8,503	158,429	43,795
1913.....	8,250	.....	100,882	2,542	.....	178,719	

MINERAL AND METALLURGICAL EXPORTS OF FRANCE. (a) (b)
(In metric tons.)

Year.	Aluminuim.	Antimony.		Arsenic.	Cement.	Coal.	Copper.		Gold. Kg.(d)
		Ore.	Metal.				Ore. (c)	Metal.	
1898	192	616	101	.....	241,150	1,320,616	1,783	14,350	1,812
1899	256	304	255	.....	244,480	1,229,090	2,078	17,949	2,622
1900	324	154	336	.....	232,577	1,201,210	9,197	16,791	883
1901	307	645	741	.....	242,010	908,583	16,066	14,776	1,869
1902	748	595	666	.....	210,590	910,700	20,489	14,423	1,517
1903	666	904	1,358	.....	233,835	2,238,735	12,487	11,403	3,139
1904	664	1,191	720	.....	260,686	2,384,928	14,258	12,663	1,537
1905	928	981	815	.....	275,503	(i)3,348,010	13,260	13,800	5,740
1906	1,522	3,541	871	.....	329,879	(i)1,448,000	8,056	6,130	11,727
1907	1,118	3,460	1,270	.....	366,624	(i)1,224,000	4,151	18,630	6,289
1908	1,332	3,300	2,129	8,600	342,131	(i)1,117,000	3,600	17,845	4,455
1909	4,425	4,000	2,408	3,267	316,486	(i)1,493,308	6,200	18,775	5,266
1910	4,148	4,583	2,163	2,411	315,020	(i)1,580,077	4,163	20,884	7,264
1911	4,058	3,991	1,945	832	333,043	(i)1,635,000	8,335	22,690	.....
1912	6,605	1,673	2,890	1,497	361,425	(i)2,320,349	6,374	42,307	775
1913	.....	608	.....	1,850	.....	.....	10,154	.....	.....

Year.	Iron.				Lead.		Manganese Ore.
	Ore.	Pig.	Bars.	Steel.	Ore.	Metal.	
1898	236,169	162,991	27,424	47,278	10,216	3,663	12,229
1899	291,346	153,792	29,112	33,584	3,909	1,163	12,289
1900	371,799	114,361	18,763	19,535	2,345	958	8,392
1901	258,925	96,463	25,220	56,347	3,490	718	5,289
1902	422,677	213,081	23,828	121,932	2,414	648	1,948
1903	714,173	196,444	40,533	215,737	2,313	13,048	717
1904	1,219,149	191,819	40,374	246,738	1,880	13,467	1,392
1905	1,355,932	218,227	67,240	343,612	3,064	12,903	662
1906	1,759,443	143,142	58,826	236,617	1,354	997	4,103
1907	2,147,000	249,708	84,557	291,434	1,210	1,912	5,167
1908	2,384,000	171,797	86,691	360,509	6,700	1,974	1,000
1909	3,907,338	161,058	96,999	318,925	2,800	2,458	1,149
1910	4,892,542	110,086	122,543	(k)302,168	5,855	3,004	722
1911	6,160,100	104,350	171,000	100,000	9,691	2,660	902
1912	8,318,312	216,895	67,000	170,000	12,276	1,660	2,282
1913	.....	.....	.....	.....	14,283	.....	1,705

Year.	Nickel, Refined.	Phosphate Rock.	Plaster.	Pyrite.	Silver, Kg. (e)	Tin (Metal).	Zinc.	
							Ore.	Spelter, Sheets and Scrap.
1899	280	70,517	112,520	53,395	.....	666	76,104	14,958
1900	599	89,135	108,387	64,530	15,470	716	54,663	12,712
1901	1,031	81,405	101,063	52,952	16,745	438	42,995	15,023
1902	397	62,375	110,270	63,920	17,184	654	47,724	16,158
1903	720	72,252	131,245	119,173	43,690	1,994	62,731	12,657
1904	906	78,612	139,551	40,833	23,105	2,300	57,780	19,063
1905	1,583	55,240	124,561	21,257	66,904	2,611	72,512	17,802
1906	1,088	81,660	142,339	26,216	87,952	601	67,258	19,607
1907	1,414	100,508	137,356	24,417	58,199	729	54,316	21,938
1908	1,230	71,509	132,924	40,300	56,957	810	57,800	20,589
1909	1,940	47,611	120,701	40,200	56,549	886	60,000	24,729
1910	2,050	44,384	152,390	56,735	58,294	1,224	56,800	22,975
1911	880	31,413	148,952	68,919	17,256	1,520	51,737	25,500
1912	1,192	22,062	174,486	43,905	3,856	1,450	60,007	34,124
1913	.....	21,128	.....	.....	.....	.....	58,203	.....

(a) From *L'Economiste Francais* (representing the *Commerce Spécial*) except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation*. (b) Not reported. (c) Includes matte. (d) Gold and platinum in sheets, leaves, threads or jewelry and crude platinum. (e) Silver in sheets, leaves, wire and jewelry. (f) Includes bitumen, bituminous schist and sand and asphaltic limestone. (g) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (h) Includes chromate of soda. (i) Includes coke. (k) From *Statistique de l'Industrie Minérale* in the years 1908, 1909, 1910. Steel in 1910 not classified as before. 1911, from *l'Echo des Mines et Metallurgie*.

GERMANY

The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF GERMANY. (a)

Year.	Alum.	Aluminium. Sulphate	Arsenic.		Asphaltum.	Boracite.	Cadmium. Kg.	Coal.	
			Ore.	Salts.				Bituminous.	Lignitic.
1899	3,358	37,693	3,834	2,423	74,770	183	13,608	101,639,753	34,204,666
1900	4,355	44,372	4,379	2,415	89,685	232	13,553	109,290,237	40,498,019
1901	4,145	46,807	4,035	2,549	90,193	184	13,144	108,539,444	44,479,970
1902	4,108	47,905	3,959	2,828	88,374	196	12,625	107,473,933	43,126,281
1903	3,934	49,727	4,369	2,768	87,454	159	16,565	116,637,765	45,819,488
1904	3,850	55,881	4,390	2,829	91,736	135	25,245	120,815,503	48,635,080
1905	4,127	52,892	4,913	2,535	103,006	183	24,568	121,298,607	52,512,062
1906	4,494	55,969	6,249	3,052	117,413	161	21,486	137,117,926	56,419,567
1907	4,200	59,473	4,878	2,904	126,649	114	32,949	143,185,691	62,546,671
1908	3,802	53,958	6,065	2,822	89,009	128	32,995	147,671,149	67,615,200
1909	4,179	56,096	6,150	2,911	77,537	149	37,187	148,788,050	68,657,606
1910	4,406	58,349	6,151	3,066	81,208	167	41,100	152,827,777	69,473,883
1911	3,076	.....	4,859	2,981	81,902	160	42,000	160,747,580	73,760,867
1912	.....	.....	4,869	.....	96,117	224	43,000	174,875,297	80,934,797

Year.	Cobalt, Nickel and Bismuth Ores.	Copper.				Gold.	Graphite.
		Ore.	Matte. (b)	Ingots.	Sulphate.		
1899	1,270	733,619	95	34,634	5,142	$1,731,153	5,196
1900	4,495	747,749	4,207	30,929	5,076	2,030,200	9,248
1901	10,479	777,339	365	31,317	5,192	1,830,835	4,435
1902	12,433	761,921	447	30,578	4,997	1,770,361	5,023
1903	14,607	772,695	583	31,214	5,200	1,709,223	3,720
1904	14,016	798,214	641	30,264	6,584	1,819,538	3,784
1905	10,848	793,488	1,635	31,713	6,988	2,611,812	4,921
1906	.....	768,523	771	32,275	6,757	2,931,750	4,055
1907	2,809	771,227	527	31,946	5,284	3,111,379	4,033
1908	8,535	727,384	328	30,001	7,117	3,162,544	4,844
1909	10,388	798,618	2,242	31,126	6,211	3,366,986	6,774
1910	10,313	925,957	3,735	34,926	5,210	3,227,250	7,415
1911	.....	868,600	1,142	37,452	7,353	3,302,300	11,298
1912	12,861	969,330	2,574	49,447	5,955	3,322,700	12,532

Year.	Iron and Steel.				Lead.		
	Iron Ore.	Pig Iron. (c)	Wrought iron and Steel.	Sulphate. (d)	Ore.	Pig.	Litharge.
1899	17,989,635	8,153,133	7,532,524	10,931	144,370	129,225	3,562
1900	18,964,294	8,520,540	7,377,275	10,913	148,257	121,513	3,088
1901	16,570,182	7,880,087	7,033,438	11,148	153,341	123,098	4,101
1902	17,963,591	8,529,900	8,317,231	.....	167,855	140,331	4,197
1903	21,230,650	10,017,901	9,226,898	12,243	165,991	145,319	4,428
1904	22,047,393	10,058,273	9,239,302	13,585	164,440	137,580	4,332
1905	23,444,073	10,875,061	10,309,690	12,949	152,725	152,590	3,786
1906	26,734,570	12,292,819	11,307,807	13,376	140,914	150,741	4,137
1907	27,697,127	12,875,159	12,063,632	14,033	147,272	142,271	4,325
1908	24,278,151	11,805,321	10,930,933	15,738	156,861	164,079	5,339
1909	25,505,409	12,917,653	11,719,239	21,838	159,852	167,920	3,059
1910	28,709,700	14,502,183	12,988,177	18,677	148,497	159,851	3,581
1911	29,879,361	15,280,527	14,384,271	17,002	140,154	161,287	3,687
1912	27,199,944	15,220,881	16,508,987	.....	142,839	192,618	4,135

Year.	Magnesium Salts.		Manganese Ore.	Petroleum.	Potassium Salts.				
	Chloride.	Sulphate.			Chloride.	Kainite. (f)	Sulphate.	Potassium-Magnesium Sulphate.	Other than Kainite.
1899	21,370	39,540	61,329	27,027	207,506	1,108,159	26,103	9,765	1,384,972
1900	19,397	48,591	59,204	50,375	271,512	1,227,873	30,853	15,368	1,822,758
1901	21,018	46,714	56,691	44,095	294,666	1,498,589	37,394	15,612	2,036,325
1902	19,658	39,262	49,812	49,725	267,512	1,322,623	28,278	18,147	1,962,384
1903	22,990	37,844	47,994	62,680	280,248	1,557,243	36,674	23,631	2,073,720
1904	25,730	39,412	52,886	89,620	297,238	1,905,893	43,959	29,285	2,179,471
1905	29,017	58,568	51,463	78,869	373,177	2,387,643	47,994	34,222	2,655,845
1906	38,468	43,041	52,485	81,350	403,387	2,720,594	54,490	35,211	2,821,073
1907	32,891	41,105	73,105	106,379	473,138	2,624,412	60,292	33,368	3,124,955
1908	29,775	42,977	67,692	141,900	511,258	2,715,487	55,756	33,149	3,383,535
1909	31,526	53,812	77,177	143,244	624,994	3,181,349	68,539	38,722	3,969,554
1910	32,207	57,314	80,560	145,168	741,259	4,249,657	84,583	37,438	4,062,004
1911	36,764	55,179	87,297	142,992	838,420	4,425,497	107,631	42,253	5,181,379
1912	85,387	99,442	185	134,986	506,744	.....	123,407	54,435	.....

Year.	Pyrite.	Salt.		Silver and Gold Ore.	Silver. *Kg.*	Sodium Sulphate.	Sulphur.	Sulphuric Acid.
		Rock.	Evaporated.					
1899	144,623	861,123	571,058	13,506	467,590	79,062	1,663	813,141
1900	169,447	926,563	587,464	12,593	415,735	90,468	1,445	829,376
1901	157,433	985,050	578,751	11,577	403,796	76,066	963	835,000
1902	165,225	1,010,412	572,846	11,724	430,610	90,742	.....	894,409
1903	170,867	1,095,541	598,394	11,467	396,253	83,087	219	928,190
1904	174,782	1,079,868	621,064	10,405	389,827	75,171	209	963,384
1905	185,368	1,165,495	612,062	10,286	399,775	68,454	205	1,228,211
1906	196,971	1,235,041	635,171	8,066	393,442	81,175	178	1,335,128
1907	196,351	1,285,137	665,547	8,280	386,933	80,347	176	1,402,398
1908	219,456	1,331,984	665,651	7,653	407,185	72,667	811	1,391,653
1909	198,688	1,370,668	647,939	7,510	400,562	71,813	1,185	1,434,709
1910	215,708	1,424,064	669,120	6,646	420,003	84,787	1,272	1,616,336
1911	217,459	1,436,492	645,991	4,890	439,580	82,664	1,251	1,534,455
1912	242,121	1,352,524	671,622	595	.....	.....	.....	1,649,681

Year.	Tin.			Uranium and Tungsten Ores.	Zinc.		
	Ore.	Block.	Chloride.		Ore.	Spelter.	Sulphate.
1900	80	2,031	(g) 143	43	639,215	155,790	6,027
1901	82	1,464	(g) 135	43	647,496	166,283	5,552
1902	104	2,779	.....	31	702,504	174,927	.....
1903	110	3,065	1,064	35	682,853	182,548	5,994
1904	99	4,216	816	23	715,732	193,058	6,185
1905	123	5,233	811	26	731,271	198,208	5,896
1906	.....	6,597	987	.....	704,590	205,691	6,092
1907	.....	5,838	1,812	3	698,425	208,195	5,145
1908	111	6,374	2,266	42	706,441	216,490	5,310
1909	124	8,994	3,247	98	723,565	219,766	5,574
1910	125	11,395	3,391	95	718,316	221,395	6,308
1911	.....	12,412	3,749	.....	699,970	235,776	6,703
1912	(i)	10,646	3,094	70	643,598	269,161	6,413
1913	.....	.....	.....	.....	637,308	.....	.....

(a) From the *Vierteljahrshefte zur Statistik des Deutschen Reichs.* Where gold is reported 1 mark = $0.238. (b) Includes black copper. (c) Includes ferromanganese and spiegeleisen. (d) Contains a small quantity of copper and iron sulphate mixed. (f) Compound of potassium chloride and magnesium sulphate. (g) Includes nickel sulphate. (i) Included with cobalt, nickel and bismuth.

MINERAL PRODUCTION OF BADEN. (a)
(In metric tons and dollars; 4 marks = $1.)

Year.	Aluminium Sulphate.	Barytes.	Coal.	Gypsum.	Manufacturers of Iron.		
					Cast, Foundry.	Steel.	Wrought.
1899....	2,153	2,430	4,700	29,419	53,608	3,830	1,402
1900....	2,286	2,970	4,930	26,381	50,102	3,532	1,364
1901....	2,260	3,991	3,650	28,183	40,100	8,739	1,158
1902....	2,374	6,234	2,078	33,150	40,973	12,663	1,052
1903....	2,498	8,857	1,990	29,423	45,233	7,666	863
1904....	2,392	9,078	1,485	26,984	64,320	7,687	783
1905....	2,581	11,094	668	28,823	74,128	8,053	842
1906....	2,583	11,984	1,000	25,643	81,387	11,068	466
1907....	2,644	9,303	2,075	29,153	98,430	10,818	533
1908....	2,524	(c) 8,554	2,473	35,217	83,724	10,430	602
1909....	2,329	(c) 15,186	2,356	36,621	83,458	11,643	484
1910....	2,141	(c) 13,832	1,650	41,078	95,795	12,134	239
1911....	2,554	15,014	(b)	42,408	107,784	11,909	244
1912....	.....	15,871	.....	51,778	.....	.....	.....
1913....	.....	16,445	.....	49,767	.....	.....	.....

Year.	Lead Ores.	Salt.	Sulphuric Acid.	Tripoli.	Zinc Ore.
1899.....	(b)	31,197	13,660	12	357
1900.....	67	32,699	15,938	9	3,004
1901.....	369	32,835	17,081	8	2,870
1902.....	450	32,192	19,265	11	2,958
1903.....	350	32,383	19,755	11	3,171
1904.....	265	32,148	35,517	12	5,063
1905.....	264	31,393	40,781	12	4,046
1906.....	246	31,288	38,655	15	1,466
1907.....	278	32,078	42,831	25	2,198
1908.....	329	33,993	41,455	13	2,793
1909.....	372	34,040	42,219	14	3,253
1910.....	419	32,729	56,069	7	3,345
1911.....	191	32,118	47,796	14	3,067
1912.....	428	32,326	.....	14	3,730
1913.....	480	33,502	.....	13	3,882

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Badschen Staate.* (b) Not reported. (c) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA. (a)
(In metric tons; 4 marks = $1.)

Year.	Barytes.	Kaolin.	Coal.	Coal. (Lignite).	Copperas and Other Sulphate.	Emery.	Feldspar.	Fluor-spar.	Graphite.
1898..	4,339	29,196	964,611	38,663	886	280	1,949	4,440	4,593
1899..	6,214	25,822	1,004,421	35,736	900	399	287	3,631	5,196
1900..	10,515	58,795	1,185,296	39,165	916	414	460	7,456	9,248
1901..	8,711	35,450	1,203,792	25,224	590	366	788	5,220	4,435
1902..	8,034	92,073	1,233,568	27,337	691	225	447	5,460	5,023
1903..	8,642	88,140	1,356,556	25,189	814	220	1,060	3,410	3,719
1904..	9,411	95,160	1,341,925	53,517	893	265	1,866	4,770	3,784
1905..	10,030	99,910	1,317,951	154,128	844	255	1,710	4,413	4,921
1906..	19,817	98,138	1,381,175	140,290	836	320	1,740	5,570	4,055
1907..	21,500	115,387	1,495,895	286,256	850	326	2,125	4,780	4,033
1908..	17,195	68,551	647,639	1,209,110	910	245	5,859	5,480	4,844
1909..	17,920	187,312	694,191	1,242,088	1,094	305	3,151	5,580	6,774
1910..	24,711	107,660	713,994	1,299,970	1,333	270	2,620	5,132	7,415
1911..	26,234	70,512	763,172	1,548,465	.....	210	3,165	4,680	11,298
1912..	27,199	72,517	790,680	1,704,654	.....	260	6,666	4,220	12,532

Year.	Gypsum.	Iron.						Lithographic Limestone.
		Ore.	Bar.	Cast, 1st Fusion.	Cast, 2d Fusion.	Pig.	Steel.	
1899....	29,727	181,981	61,415	(b)	92,459	83,821	134,007	11,982
1900....	35,484	178,441	49,727	29	89,692	82,327	135,411	16,030
1901....	3,581	158,820	29,978	76	76,191	72,071	109,464	9,500
1902....	31,701	157,375	38,429	56	81,874	83,123	115,354	.....
1903....	30,894	162,500	36,853	41	89,804	90,168	127,141	9,880
1904....	22,766	180,342	37,780	40	108,025	92,200	125,483	13,836
1905....	46,247	182,389	36,459	24	112,875	94,242	134,755	11,360
1906....	50,763	203,596	38,508	.....	122,115	97,812	150,129	.....
1907....	48,975	277,280	36,883	*Nil.*	138,659	98,143	150,148	11,580
1908....	51,314	278,681	30,740	*Nil.*	128,234	131,404	176,085	9,858
1909....	51,630	279,514	33,448	*Nil.*	130,129	134,133	219,606	9,420
1910....	54,397	303,844	30,881	*Nil.*	148,261	133,679	249,198	9,790
1911....	60,390	375,409	165,683	*Nil.*	171,976	.....	339,401	8,175
1912....	57,114	450,074	(c)	.....	396,656	[195,606	998,624	9,903

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (b) Not reported. (c) With cast iron.

Year.	Marl. (For Cement).	Mineral Paint and Chalk.	Pyrites.	Rock Salt.	Soapstone.	Sodium Sulphate.	Sulphuric Acid.
1899....	220,716	9,287	2,516	802	2,197	1,570	123,273
1900....	180,032	11,507	2,120	1,298	1,977	1,821	123,910
1901....	76,663	84,929	2,649	1,319	2,291	1,893	115,775
1902....	178,301	13,947	2,635	832	.....	.....	.....
1903....	200,407	19,486	2,324	879	1,866	.....	.....
1904....	170,698	19,107	3,427	1,139	1,709	.....	.....
1905....	231,310	18,285	3,301	911	1,872	.....	.....
1906....	230,271	22,304	3,918	1,053	.....	.....	.....
1907....	230,583	21,219	5,085	1,393	1,999	1,439	161,868
1908....	307,820	21,310	4,037	1,285	2,199	1,743	149,079
1909....	276,974	21,692	2,952	1,860	2,329	1,265	178,371
1910....	273,727	22,357	4,466	1,192	3,063	1,416	171,131
1911....	265,899	24,258	6,316	782	3,431	2,061	170,039
1912....	341,068	30,033	6,531	1,162	[3,221	.....	254,708

MINERAL PRODUCTION OF PRUSSIA. (a)

(Metric tons; 4 marks = $1.)

Year.	Alum Shale.	Antimony and Alloys.	Arsenic Products.	Arsenic Ore.	Asphalt.	Boracite.	Cadmium. *Kg.*	Coal.
1899....	145	3,003	1,469	3,265	16,458	171	13,608	94,740,829
1900....	103	3,025	1,585	3,531	23,891	217	13,533	101,966,158
1901....	611	2,404	1,446	3,050	26,450	164	13,144	101,203,807
1902....	219	3,542	1,514	2,909	28,035	172	12,625	100,115,315
1903....	580	3,224	1,583	3,538	23,518	135	16,565	108,809,384
1904....	106	2,774	1,573	3,527	26,348	115	25,245	112,755,631
1905....	97	2,795	1,493	4,022	28,872	151	24,568	113,000,657
1906....	634	2,953	1,551	5,430	32,270	124	21,486	128,295,948
1907....	154	3,515	1,591	4,224	39,243	90	32,949	134,044,089
1908....	80	3,596	1,646	5,015	27,444	105	32,995	139,002,378
1909....	60	3,841	1,849	5,731	19,509	123	37,187	139,906,194
1910....	46	4,969	2,068	5,789	21,595	138	41,068	143,771,613
1911....	63	5,411	1,862	4,476	19,956	147	42,575	151,324,080
1912....	104	.....	.....	4,870	21,241	.....	.....	165,302,784

Year.	Coal. (Lignite.)	Cobalt Ore.	Cobalt Products.	Copper.	Copper and Iron Sulphate.	Copper Ore.	Copper Matte.
1899....	28,418,598	17	46	20,902	154	722,884	95
1900....	34,007,542	4	52	27,156	113	747,601	4,207
1901....	37,491,412	36	66	28,422	78	765,241	281
1902....	36,228,285	76	74	27,893	119	751,496	346
1903....	38,462,766	65	87	28,386	110	761,188	488
1904....	41,153,576	41	85	27,450	95	782,049	601
1905....	44,148,751	22	99	28,874	102	769,381	1,052
1906....	47,912,721	7	98	29,166	94	755,812	525
1907....	52,660,597	*Nil.*	109	28,945	64	755,203	499
1908....	55,456,860	*Nil.*	100	27,301	50	711,921	296
1909....	56,029,554	*Nil.*	93	28,523	55	798,448	1,935
1910....	56,644,291	*Nil.*	94	30,244	44	914,519	2,060
1911....	60,531,943	*Nil.*	107	30,986	27	919,827	996
1912....	65,803,959	*Nil.*	.....	.....	.....	967,785	.....

Year.	Copper Sulphate.	Epsom Salt.	Gold. *Kg.*	Iron.	Iron Ore.	Iron Sulphate.	Lead.
1899.....	1,586	1,793	1,016.4	5,644,614	4,295,575	10,186	116,995
1900.....	1,660	1,511	1,076.6	5,781,892	4,268,069	10,225	112,738
1901.....	1,951	1,952	1,087.1	5,315,628	3,831,670	10,239	113,939
1902.....	1,937	761	1,138.0	5,633,089	3,362,887	11,214	127,283
1903.....	2,254	421	949.5	6,614,768	3,786,743	11,086	133,405
1904.....	3,364	289	1,081.9	6,573,507	3,757,651	12,524	128,294
1905.....	3,065	338	1,034.9	7,106,975	4,130,210	12,075	143,270
1906.....	2,724	144	750.2	8,154,880	4,713,928	12,473	140,690
1907.....	2,129	263	771.0	8,266,300	5,077,773	13,014	132,366
1908.....	3,116	398	786.6	7,989,260	4,311,593	14,062	153,541
1909.....	2,500	395	588.2	8,410,824	4,389,950	18,295	156,533
1910.....	1,749	162	566.3	9,995,012	4,823,606	16,119	146,993
1911....	2,464	114	520.	10,477,283	4,948,711	15,468	147,538
1912.....	.....	.....	.....	.....	5,248,766	.....	.....

Year.	Lead ore.	Litharge.	Manganese Ore.	Nickel.	Nickel Ore.	Nickel Sulphate.	Ocher and Mineral Paints.
1899.....	128,942	2,482	60,379	1,115	91	123	2,770
1900.....	133,483	2,366	58,016	1,376	3,896	115	2,850
1901.....	139,285	2,885	55,866	1,660	9,922	120	2,800
1902.....	152,282	2,516	48,882	1,605	11,816	159	2,780
1903.....	151,746	2,710	47,110	1,945	14,058	173	2,850
1904.....	150,328	2,517	52,092	2,333	13,518	207	3,200
1905.....	138,928	2,272	51,048	2,631	10,432	220	3,170
1906.....	127,322	2,744	51,881	2,648	7,472	187	3,635
1907.....	133,528	2,959	72,442	2,093	7,557	189	3,707
1908.....	141,316	4,190	67,241	2,622	8,238	181	3,183
1909.....	158,811	2,365	76,741	3,186	10,095	163	3,435
1910.....	146,830	3,076	80,325	3,497	10,053	213	142
1911.....	135,366	3,441	86,902	3,744	9,609	244	.....
1912.....	140,158	.....	[92,474	.....	12,113	.....	.....

Year.	Petroleum.	Potassium salts.		Pyrite.	Quicksilver. *Kg.*	Salt.	
		Kainite.	All other.			Common.	Rock.
1899.....	3,405	744,657	941,055	134,564	2,611	288,588	331,943
1900.....	27,731	857,271	1,264,993	159,186	1,711	287,005	354,603
1901.....	24,098	1,068,237	1,131,703	148,457	1,713	290,869	353,557
1902.....	29,520	943,450	1,344,541	155,410	1,828	291,296	359,006
1903.....	41,733	1,118,270	1,344,038	159,234	2,145	317,475	409,199
1904.....	67,604	1,261,930	1,447,323	163,209	3,030	328,933	394,910
1905.....	57,741	1,580,530	1,734,033	174,641	2,597	328,051	436,942
1906.....	59,196	1,923,088	1,937,181	186,849	5,084	339,675	492,339
1907.....	80,255	1,839,409	2,070,978	184,962	5,080	353,290	480,563
1908.....	113,002	2,037,203	2,192,188	204,992	4,423	359,003	478,346
1909.....	113,518	2,431,401	2,436,319	189,773	5,213	344,685	491,071
1910.....	110,996	3,119,400	2,584,565	203,596	4,492	351,698	500,978
1911.....	98,611	3,502,762	2,920,725	203,249	2,861	337,583	527,034
1912.....	87,443	4,256,476	3,287,177	233,397	.....	343,883	527,275

Year.	Silver. *Kg.*	Silver and Gold Ores.	Sulphur.	Sulphuric Acid.	Tin.	Zinc.		
						Ore.	Metal.	Sulphate.
1899.....	293,858	7	1,419	573,733	1,461	663,763	152,987	4,864
1900.....	266,577	1	1,207	593,109	2,010	636,068	155,760	3,742
1901.....	246,286	6	772	609,041	1,443	644,504	166,223	3,369
1902.....	273,901	17	250	677,798	2,753	699,392	174,892	3,381
1903.....	255,722	13	16	724,784	3,042	679,320	182,472	3,586
1904.....	252,020	8	16	868,424	4,193	710,599	192,903	3,696
1905.....	266,072	4	14	921,219	5,196	727,104	198,179	3,506
1906.....	264,427	239	16	980,188	6,570	702,933	205,632	3,630
1907.....	249,348	34	7	1,004,599	5,819	696,039	207,849	3,057
1908.....	274,154	7	706	997,931	5,330	703,394	212,991	3,223
1909.....	271,779	2	1,096	1,006,787	8,943	720,139	214,551	3,434
1910.....	277,777	0.2	1,239	1,164,015	11,345	714,855	216,362	3,875
1911.....	277,981	.....	1,239	1,219,879	12,335	696,903	230,995	4,127
1912.....	.....	.....	.....	.....	.....	647,081	.....	.....

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*

MINERAL IMPORTS OF GERMANY. (*a*)

Year.	Aluminium Refined and Crude.	Ammonium Sulphate.	Antimony.	Antimony and Arsenic Ores.	Asbestos, Crude.	Asphalt.	Bituminous Rock.	Barium Chloride.	Barytes (*b*)
1901 ...	1,090	44,408	1,494	1,098	5,500	62,299	41,733	1,768	5,764
1902 ...	1,100	42,252	1,495	1,231	3,415	88,536	36,791	2,135	5,040
1903 ...	1,155	35,168	2,281	1,741	5,727	94,377	40,873	2,374	5,534
1904 ...	2,422	35,166	2,003	1,687	5,251	85,049	38,812	2,428	6,742
1905 ...	3,252	48,005	1,680	567	7,830	3,461	64,196	2,114	7,981
1906 ...	3,886	35,366	2,044	2,417	9,828	15,095	118,238	2,559	17,246
1907 ...	3,974	33,522	2,496	4,913	11,096	4,793	128,257	2,781	12,588
1908 ...	3,204	47,265	2,670	2,073	10,034	2,587	130,063	2,256	19,969
1909 ...	8,696	58,132	2,719	2,912	11,928	1,209	98,378	1,907	14,560
1910 ...	9,892	31,400	2,982	3,347	11,729	2,932	117,763	1,955	5,782
1911 ...	10,454	24,463	3,607	6,429	12,334	133,635	17,476	2,002	7,926
1912 ...	18,112	23,098	3,400	2,891	14,790	147,784	18,409	3,674	18,646
1913 ...	15,508	34,627	3,604	3,700	14,658	145,351	.....	2,598	19,466

Year.	Borax.	Bauxite.	Calcium Carbide.	Cement.	Chalk (*d*), Crude White.	Chrome Ore.	Coal.		Coke.
							Bitum., Arthracite Cannel.	Lignitic.	
1901 ...	2,537	24,113	9,526	87,262	(*d*)29,611	18,222	6,297,389	8,108,943	400,197
1902 ...	2,057	26,698	11,287	52,018	(*d*)26,408	10,152	6,425,658	7,882,010	382,488
1903 ...	2,567	22,316	14,081	49,870	(*d*)33,362	13,919	6,766,513	7,962,123	432,819
1904 ...	2,603	27,849	14,840	60,188	(*d*)32,581	18,132	7,299,042	7,669,099	550,302
1905 ...	2,802	39,137	17,256	148,118	(*d*)35,529	11,998	9,399,693	7,945,261	713,619
1906 ...	3,044	43,177	22,819	233,119	18,871	17,124	9,253,711	8,430,441	565,561
1907 ...	2,014	59,989	25,834	241,475	16,035	19,508	13,729,849	8,963,103	584,220
1908 ...	1,903	48,064	29,024	168,504	17,606	16,974	11,661,503	8,581,966	575,091
1909 ...	2,550	45,543	26,956	224,178	15,924	22,018	12,198,634	8,166,479	673,012
1910 ...	3,181	56,287	30,712	242,663	17,700	24,470	11,195,593	7,397,719	622,452
1911 ...	5,358	37,155	36,994	253,023	23,717	16,022	10,913,948	7,069,064	598,958
1912 ...	7,978	36,348	47,984	228,896	28,031	23,201	10,380,482	7,266,116	589,713
1913 ...	7,381	38,452	46,725	168,449	32,546	23,251	10,540,018	6,986,681	592,661

Year.	Peat and Peat Coke.	Briquettes.	Cobalt and Nickel Ore.	Copper.				Copperas	Cryolite.
				Ore. and Matte.	Ingots.	Bars, Wire and Sheets.	Sulphate.		
1901 ...	15,102	92,037	12,186	4,614	58,620	786	1,211	501	1,249
1902 ...	16,696	81,854	14,630	14,630	76,050	540	2,499	807	1,332
1903 ...	14,640	84,635	36,927	13,714	83,261	568	1,691	778	1,082
1904 ...	9,071	125,477	14,555	7,949	110,231	719	1,735	765	1,139
1905 ...	11,439	191,753	39,590	10,137	102,218	927	2,180	666	1,143
1906 ...	19,428	162,650	22,557	9,941	126,071	409	1,702	621	(*k*)
1907 ...	15,238	195,403	29,296	19,295	124,116	772	4,519	1,165	(*k*)
1908 ...	15,266	192,391	17,402	17,456	157,669	952	5,078	7,234	(*k*)
1909 ...	13,208	211,058	10,186	26,488	154,673	416	6,550	5,954	(*k*)
1910 ...	16,188	241,267	9,937	22,194	181,551	403	3,952	4,336	(*k*)
1911 ...	14,517	210,933	14,897	23,327	191,590	520	4,145	3,323	(*k*)
1912 ...	11,040	187,736	14,987	23,192	200,608	332	7,074	5,925	(*k*)
1913 ...	11,796	147,416	13,658	27,594	225,392	.....	3,869	2,954	(*k*)

Year.	Gold, Silver and Platinum Ores.	Graphite	Gypsum.	Iodine.	Iron.		Lead.		
					Ore.	Pig.	Ore.	Pig and Scrap.	Lead White.
1901 ...	8,764	17,374	7,622	266	4,370,022	267,503	100,196	52,886	423
1902 ...	6,585	19,392	8,177	220	3,957,403	143,040	71,078	39,006	357
1903 ...	4,386	20,953	8,328	320	5,225,336	158,347	67,573	52,440	442
1904 ...	5,960	23,533	9,550	272	6,061,127	178,256	83,807	61,388	622
1905 ...	6,225	26,143	11,247	377	6,085,196	158,700	92,667	78,528	2,488
1906 ...	4,819	28,175	11,062	297	7,629,730	409,083	90,027	71,191	2,342
1907 ...	3,601	29,405	14,662	147	8,476,076	443,624	137,861	75,200	3,037
1908 ...	1,922	34,491	14,599	194	7,732,949	252,779	133,597	77,218	3,558
1909 ...	1,759	29,191	11,285	369	8,366,599	134,230	111,017	76,930	2,890
1910 ...	2,552	30,733	10,873	363	9,816,822	136,330	112,151	81,541	2,780
1911 ...	2,947	32,812	11,973	303	10,812,595	129,850	143,598	100,515	3,938
1912 ...	2,200	37,633	10,628	260	12,120,090	135,722	122,847	93,585	2,709
1913 ...	1,932	37,168	8,818	258	14,019,045	124,236	142,977	83,781	1,980

Year.	Magnesite.	Manganese Ore.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum products.		Phosphorus.
						Illuminating Oil.	Lubricating Oil.	
1901....	8,897	204,420	9,403	1,947	1,981	985,904	118,999	313
1902....	12,237	222,010	7,719	1,458	1,585	1,006,829	125,667	350
1903....	14,958	204,647	9,888	1,507	1,663	1,067,697	147,837	222
1904....	15,877	223,709	10,494	1,712	1,300	1,076,324	142,929	220
1905....	19,459	255,760	11,473	1,955	1,114	1,070,252	143,926	198
1906....	25,527	262,311	3,960	3,478	1,303	984,134	180,989	208
1907....	30,857	331,171	2,166	2,182	1,653	1,115,205	226,609	165
1908....	28,305	393,327	1,635	3,058	1,447	1,123,632	216,887	141
1909....	29,994	334,133	13,804	3,745	1,447	1,085,839	216,987	179
1910....	40,218	384,445	15,100	4,606	1,729	1,135,886	230,516	169
1911....	47,930	487,872	15,703	2,598	1,591	955,482	260,242	200
1912....	69,064	420,709	17,874	2,027	1,479	795,011	241,030	205
1913....	64,974	680,371	18,971	3,315	1,363	745,466	248,035	209

Year.	Phosphate Rock.	Potassium salts.							Pumicestone (g)	Pyrite.
		Chloride.	Cyanide. (f)	Iodide.	Nitrate.	Carbonate.	Hydroxide.	Sulphate.		
1901....	351,155	462	2	1,529	1,758	1,529	165	680	2,336	488,633
1902....	430,043	261	3	10	1,889	2,112	42	266	2,070	482,095
1903....	461,092	40	3	8	2,163	1,850	52	81	2,697	519,317
1904....	508,634	47	2	10	2,349	1,955	61	121	3,000	503,503
1905....	501,048	223	3	30	2,156	1,693	24	131	3,240	552,184
1906....	531,195	181	3	18	1,918	2,099	44	257	5,463	579,355
1907....	579,505	1,615	1	8	1,815	2,304	92	141	5,443	742,826
1908....	736,127	49	4	7	2,200	1,773	50	169	6,154	659,871
1909....	663,400	55	2	4	2,853	1,750	64	101	6,639	691,213
1910....	723,271	72	2	8	1,979	2,366	63	66	7,446	702,735
1911....	831,027	1,160	33	13	2,114	2,616	67	61	9,659	862,214
1912....	902,844	46	5	11	597	2,321	62	44	8,365	1,073,285
1913....	928,798	15	3	13	402	2,760	42	44	8,801	1,022,952

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.			Strontianite. (a)
				Soda, Calcined.	Nitrate (Chile Saltpeter.)	Sulphate and Sulphite.	
1901.....	651	23,901	733,931	178	529,568	7,921	19,739
1902.....	648	26,404	831,282	121	467,024	7,308	34,035
1903.....	674	20,118	877,394	114	467,130	6,058	24,183
1904.....	691	18,743	846,738	179	506,172	9,598	18,055
1905.....	729	20,726	888,665	143	540,916	4,752	13,720
1906.....	698	16,997	813,388	189	593,218	7,405	5,212
1907.....	831	23,109	568,046	257	591,131	10,446	5,595
1908.....	648	24,975	562,853	293	604,457	4,404	4,211
1909.....	723	19,319	492,771	181	665,450	9,214	4,277
1910.....	836	30,443	766,320	105	749,945	9,302	4,852
1911.....	919	29,067	685,943	559	730,939	5,976	3,251
1912.....	990	17,887	1,248,693	1,987	812,898	5,609	4,259
1913.....	961	21,422	.....	2,633	774,298	10,074	3,965

Year.	Sulphur.	Sulphuric Acid.	Super-phosphate.	Tin, Crude.	Zinc.			
					Ore.	Spelter.	Drawn or Rolled.	Zinc-white, Zinc-gray, Lithophone.
1901....	32,750	18,502	107,365	12,910	75,533	21,250	306	3,673
1902....	32,798	22,205	109,374	13,760	61,407	25,946	134	3,986
1903....	41,545	13,418	82,740	13,925	67,156	25,749	237	4,667
1904....	41,030	16,087	91,288	14,352	93,515	26,389	151	6,461
1905....	39,989	33,837	109,666	13,501	126,577	29,583	54	7,802
1906....	41,390	74,536	76,384	14,098	178,953	39,314	97	9,140
1907....	44,700	59,753	62,877	12,814	184,703	28,459	134	10,189
1908....	44,066	61,391	71,879	14,039	199,840	32,622	286	7,080
1909....	42,941	74,384	80,512	13,537	201,110	44,514	99	7,002
1910....	46,796	86,743	78,873	14,297	240,584	39,328	246	9,239
1911....	46,054	99,653	71,119	14,500	262,399	48,355	467	7,697
1912....	42,284	98,573	62,400	15,550	293,090	56,937	1,003	9,367
1913....	46,737	130,257	53,193	14,261	313,269	57,641	725	9,108

MINERAL EXPORTS OF GERMANY. (a)

Year.	Aluminium Refined and crude.	Aluminium Wares, etc.	Aluminum Sulphate.	Ammonium.		Antimony and Arsenic Ores.	Antimony.	
				Carbonate and Chloride.	Sulphate.		Metallic.	Salts.
1901....	282	2,270	31,171	3,196	9,842	283	76	826
1902....	410	2,608	34,005	3,351	5,744	410	105	954
1903....	353	2,865	28,513	2,778	5,592	427	83	873
1904....	407	3,077	29,311	3,106	10,696	486	250	964
1905....	1,192	3,476	34,776	3,579	27,589	287	218	1,097
1906....	1,111	1,321	25,937	3,555	37,288	548	221	997
1907....	1,119	1,142	24,759	3,118	57,439	930	255	1,168
1908....	590	642	22,376	1,161	73,186	588	146	1,030
1909....	492	1,273	58,723	1,093	58,722	577	160	1,090
1910....	616	1,755	93,069	1,500	93,069	571	198	1,047
1911....	768	1,331	30,107	4,895	74,410	612	298	1,208
1912....	2,074	4,184	32,469	5,292	57,268	569	132	1,155
1913....	2,703	5,667	31,772	5,401	75,868	502	702	1,461

Year.	Arsenic.		Asbestos.	Barytes. (b)	Barium.		Bauxite.	Borax.	Bromine.
	Metallic.	White, etc.	Crude.		Chloride and Salts of.	White.			
1901...	28	1,534	638	67,526	6,803	2,765	137	2,563	228
1902...	46	2,036	709	56,026	7,358	2,922	32	2,836	153
1903...	32	1,903	513	72,455	8,417	3,187	19	2,779	155
1904...	50	1,956	738	69,564	8,596	3,777	21	2,741	208
1905...	40	1,753	1,173	81,134	9,550	4,382	6	2,720	156
1906...	.....	2,282	1,938	90,819	6,541	10,721	398	2,795	172
1907...	(m)45	1,733	1,707	111,209	4,189	8,454	517	3,049	118
1908...	(m)65	1,956	1,345	91,111	3,389	5,190	783	2,879	227
1909...	(m)54	1,012	1,740	90,555	5,340	4,888	1,116	2,735	206
1910...	(m)57	1,507	1,537	114,264	6,403	5,528	863	2,916	225
1911...	71	1,973	1,503	128,452	6,180	6,834	960	3,199	229
1912...	73	2,400	1,891	142,957	7,389	8,298	400	3,330	187
1913...	.....	2,612	1,461	158,065	5,649	7,647	355	3,433	239

Year.	Coke.	Peat and Peat Coke.	Briquets.	Cobalt and Nickel Ore.	Copper.			
					Ore and Matte.	Bars, Sheets and Wire.	Ingots.	Sulphate
1901....	2,096,931	11,588	529,765	96	26,678	7,700	5,097	1,942
1902....	2,182,383	13,410	697,799	3	17,031	10,599	4,678	1,366
1903....	2,523,351	16,986	895,145	1	15,986	10,715	4,333	1,880
1904....	2,716,855	14,830	917,526	83	19,235	12,594	4,223	2,231
1905....	2,761,080	16,009	936,694	107	28,908	10,006	5,958	2,180
1906....	3,415,347	15,680	1,095,029	(i)	6,414	10,728	7,241	3,018
1907....	3,792,580	25,746	1,260,135	(i)	20,950	13,411	6,113	2,016
1908....	3,577,496	26,817	1,493,054	(i)	21,729	17,209	6,868	2,994
1909....	3,444,791	23,579	1,620,460	(i)	22,437	15,395	6,495	1,290
1910....	4,125,898	20,360	1,988,177	(i)	23,751	19,351	7,654	2,108
1911....	4,555,477	35,855	2,477,492	(i)	27,396	19,669	7,106	3,346
1912....	5,850,350	60,557	2,746,536	(i)	21,514	20,245	7,854	3,812
1913....	6,411,418	86,920	3,163,742	(i)	25,221	.....	7,208	4,013

Year.	Bromine Salts.	Calcium.		Cement.	Chalk. Crude White.	Chromium.		Coal.	
		Carbide.	Chloride.			Ore.	Alum.	Bituminous Anthracite and Cannel.	Lignitic.
1901 ...	249	275	888	560,612	(d)14,134	581	1,299	15,269,267	21,718
1902 ...	357	126	1,346	699,378	(d) 8,475	846	1,758	16,101,141	21,766
1903 ...	435	335	1,831	742,381	(d)12,211	37	1,921	17,389,934	22,499
1904 ...	411	608	2,381	635,248	(d)11,359	47	2,432	17,996,726	22,135
1905 ...	634	709	2,831	675,664	(d)13,081	43	2,507	18,156,998	20,118
1906 ...	643	545	(l)	736,579	4,287	(h) 36	2,942	19,550,964	18,759
1907 ...	655	918	(l)	692,982	2,919	(h) 149	3,110	20,056,503	22,065
1908 ...	506	844	(l)	528,847	2,108	(h) 110	3,215	21,190,777	27,877
1909 ...	486	968	(l)	611,893	4,395	(h)5,023	3,023	23,350,705	39,815
1910 ...	323	1,482	(l)	725,356	3,359	(h) 386	3,998	24,257,651	62,441
1911 ...	.....	2,120	(l)	845,850	1,537	(h)1,795	2,815	27,412,218	58,071
1912 ...	372	971	(l)	1,056,622	2,890	(h) 778	3,221	31,145,057	56,966
1913 ...	405	.....	(l)	1,129,563	3,409	(h) 681	3,313	34,573,514	60,345

Year.	Copperas.	Cryolite.	Fluorspar.	Graphite.	Gypsum.	Iodine.	Iron.	
							Ore.	Pig.
1901.....	4,125	367	13,436	1,667	40,397	27	2,389,870	150,448
1902.....	4,360	486	14,177	1,691	42,859	24	2,868,068	374,256
1903.....	3,986	349	13,028	1,810	51,874	29	3,343,510	418,072
1904.....	3,514	310	13,540	1,815	55,043	30	3,440,846	225,897
1905.....	4,495	286	15,019	1,971	52,886	27	3,698,583	380,824
1906.....	4,712	(k)	15,493	2,013	63,516	46	3,851,791	479,772
1907.....	6,212	(k)	16,624	2,176	70,737	44	3,904,400	275,170
1908.....	4,393	(k)	14,925	2,469	60,992	51	3,067,737	257,849
1909.....	2,232	(k)	14,534	2,377	63,220	59	2,825,007	471,045
1910.....	2,929	(k)	17,988	3,424	89,590	70	2,952,634	786,854
1911.....	4,151	(k)	23,073	3,822	102,754	73	2,581,608	829,393
1912.....	3,386	(k)	21,145	4,501	108,624	79	2,309,638	1,016,261
1913.....	5,382	(k)	25,523	5,423	132,693	92	2,613,158	782,911

Year.	Lead.					Lime, Chloride of.	Magnesite.	Magnesium Chloride.	Manganese Ore.
	Ore.	Pig and Scrap.	Litharge.	White.	Red.				
1901 ...	891	20,820	4,876	16,966	7,776	32,705	2,485	16,102	5,584
1902 ...	2,024	23,100	4,072	19,070	8,372	29,694	2,955	14,757	4,528
1903 ...	1,270	30,243	5,175	20,765	7,617	28,849	2,812	17,008	11,138
1904 ...	1,312	23,169	5,410	16,638	7,544	30,078	1,917	16,706	5,536
1905 ...	1,496	32,515	4,466	16,478	8,902	30,667	2,552	21,673	4,116
1906 ...	1,915	27,067	2,493	14,022	9,450	29,485	2,843	26,708	2,555
1907 ...	1,296	38,259	4,470	13,651	9,371	24,946	3,264	29,566	3,554
1908 ...	1,189	29,967	5,242	13,733	9,602	23,895	4,021	27,525	2,333
1909 ...	2,556	31,674	4,750	10,583	9,058	27,314	3,702	31,334	4,488
1910 ...	2,382	31,025	4,865	13,595	10,444	24,716	5,399	35,352	4,557
1911 ...	3,746	32,063	5,436	14,962	11,321	27,107	4,496	43,896	9,615
1912 ...	3,273	38,122	6,480	12,750	10,116	32,254	7,132	39,559	7,790
1913 ...	4,458	41,369	6,203	12,402	8,898	36,473	5,857	55,505	9,388

Year.	Mineral Pigments.	Nickel.	Osokerite.	Petroleum Products. (f)		Phosphorus.	Phosphate Rock.
				Illuminating Oil.	Lubricating Oil.		
1901.....	12,671	390	1,700	655	963	149	2,260
1902.....	14,392	689	1,856	824	1,177	260	1,103
1903.....	15,161	700	2,027	701	1,975	286	4,342
1904.....	16,395	1,203	2,447	760	1,763	236	3,222
1905.....	17,603	1,034	2,757	7,286	1,746	228	3,720
1906.....	4,290	954	509	673	9,982	228	5,484
1907.....	4,097	930	692	770	10,552	165	1,494
1908.....	15,675	1,349	921	1,008	10,852	160	1,196
1909.....	18,130	1,606	1,300	588	11,621	168	5,429
1910.....	19,355	1,381	1,642	472	17,141	160	5,044
1911.....	22,426	1,592	1,295	274	18,905	192	10,591
1912.....	27,313	1,677	1,167	244	19,635	219	7,032
1913.....	30,348	1,673	1,999	.....	.....	192	6,885

Year.	Potassium Salts.						Potassium and Potassium-Magnesium Sulphate.	Pumice Stone. (g)	Pyrite
	Carbonate	Cyanide. (f)	Chloride.	Hydroxide.	Iodide.	Nitrate.			
1901 ...	15,567	2,089	118,959	14,892	145	13,439	37,216	699	23,680
1902 ...	14,041	3,257	106,925	13,804	152	9,734	40,487	691	35,370
1903 ...	13,121	2,017	125,302	13,006	154	9,671	56,455	794	32,611
1904 ...	10,777	3,290	140,765	24,963	174	10,405	64,400	943	30,666
1905 ...	11,963	4,005	156,440	22,246	170	12,140	67,286	939	35,195
1906 ...	12,543	5,049	171,994	21,772	168	11,564	54,557	1,578	35,829
1907 ...	13,314	5,210	173,638	20,254	146	12,668	128,344	2,590	24,183
1908 ...	13,009	4,887	174,345	25,048	127	10,643	181,975	6,055	16,384
1909 ...	13,797	6,283	216,286	27,095	122	12,498	201,393	9,140	11,564
1910 ...	13,099	6,329	266,783	29,094	124	14,728	273,614	7,643	9,871
1911 ...	14,584	6,554	329,751	28,921	133	16,430	392,129	22,075	11,015
1912 ...	12,991	6,718	286,614	26,623	143	14,451	134,079	19,978	27,917
1913 ...	16,271	6,678	393,320	44,113	160	16,058	192,565	4,052	28,214

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.					
				Bicarbonate.	Carbonate.	Hydroxide.	Nitrate. (Chile Saltpeter.)	Soda, Calcined.	Sulphate and Sulphite.
1901...	27	286,424	27,269	1,086	1,382	4,926	13,481	45,967	45,462
1902...	109	328,324	22,726	954	2,449	5,650	14,737	33,109	56,748
1903...	62	399,184	14,674	1,016	2,982	5,886	17,583	46,086	47,660
1904...	43	347,351	38,587	1,524	3,050	5,084	21,075	43,590	45,506
1905...	48	284,203	28,032	1,881	4,113	5,925	20,531	46,768	54,377
1906...	21	97,878	49,912	2,120	5,860	6,101	22,099	41,598	64,217
1907...	26	92,288	46,680	1,764	2,680	7,462	22,715	36,802	69,231
1908...	26	318,395	74,821	1,713	3,842	7,626	23,549	56,839	78,510
1909...	29	364,107	61,674	1,292	2,968	8,214	28,019	54,493	74,512
1910...	31	370,074	58,832	1,370	5,994	9,295	27,095	56,545	89,208
1911...	36	374,633	88,423	1,596	1,782	10,635	27,937	60,102	89,110
1912...	37	430,137	128,740	1,584	1,057	12,460	27,431	66,760	85,416
1913...	53	432,387	.....	1,869	1,354	13,030	27,507	69,993	83,239

Year.	Sodium and Potassium Salts.		Stassfurt Salts.	Strontium.		Sulphur.	Sulphuric Acid.
	Chromates.	Sulphides.		Carbonate. (m)	Salts.		
1901.....	2,791	2,763	592,347	384	1,022	621	42,853
1902.....	2,656	4,565	499,220	762	1,546	576	47,666
1903.....	2,977	5,845	501,385	819	1,389	1,052	50,109
1904.....	2,272	5,480	631,782	613	1,207	1,418	52,896
1905.....	2,133	6,569	852,454	613	1,386	1,198	48,701
1906.....	2,877	6,730	831,293	1,726	1,578	1,582	52,720
1907.....	3,016	8,103	839,889	1,462	1,671	1,501	49,950
1908.....	4,402	6,536	818,677	1,494	1,822	1,765	60,558
1909.....	4,789	7,596	946,457	2,636	1,832	1,935	63,817
1910.....	4,246	8,679	1,181,208	2,456	1,275	2,727	66,581
1911.....	5,193	7,837	1,154,974	595	.....	1,757	64,888
1912.....	5,167	7,640	.....	1,830	138	1,746	75,963
1913.....	5,667	9,226	.....	1,958	330	3,472	64,968

Year.	Superphosphate.	Tin, Crude.	Zinc.				Zinc-White, Zinc-Gray and Lithophone.
			Ore.	Spelter and Scrap.	Drawn or Rolled.	Sulphate.	
1900.....	77,118	1,626	34,941	51,899	16,709	382	20,729
1901.....	79,190	1,683	14,002	54,490	16,517	324	24,201
1902.....	77,818	2,271	46,965	70,292	17,015	430	28,400
1903.....	99,672	2,581	40,458	67,057	15,715	264	27,537
1904.....	129,925	2,965	40,488	70,063	17,917	332	26,898
1905.....	115,886	3,259	38,972	67,675	18,982	296	27,877
1906.....	104,713	4,845	42,546	69,142	17,794	426	26,296
1907.....	115,049	4,244	34,863	93,649	21,484	425	30,453
1908.....	125,464	3,707	39,450	75,290	18,661	347	26,372
1909.....	168,988	5,431	51,994	82,225	18,961	342	25,970
1910.....	211,812	7,530	59,440	8,803	26,623	334	36,350
1911.....	221,521	7,582	48,996	81,042	36,093	387	34,419
1912.....	271,349	6,368	51,242	105,328	26,379	.....	44,169
1913.....	282,653	6,437	44,731	109,606	24,965	.....	46,106

(a) From *Statistisches Jahrbuch für das Deutsches Reich*. (b) Includes celestite. (d) Includes precipitated chalk. (e) Not reported. (f) Includes sodium cyanide. (g) Includes tripoli. (h) Includes nickel ore. (i) Included under chromium ore. (k) Included under bauxite. (l) Included under magnesium chloride. (m) Includes all alkali metals. (n) Includes witherite. (o) Under copperas.

GREECE

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table: Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF GREECE. (a)
(In metric tons or dollars; 1 drachma = 20 cents.)

Year.	Chrome Ore.	Emery.	Gypsum.	Iron Ore.	Iron Ore. Manganiferous.	Lead Soft.	Lead Ore. Argentiferous.	Lead. Argentiferous.	Lead. Fume.	Lignite.
1899..	4,386	4,360	81	331,030	294,320	291	(b)	18,768	2,584	12,150
1900..	5,600	6,328	129	279,880	243,920	245	878	16,150	2,045	12,940
1901..	4,580	5,691	671	278,640	196,152	(b)	(b)	17,644	5,292	9,726
1902..	11,680	4,727	172	364,340	170,040	(b)	430	14,048	1,647	6,500
1903..	8,478	5,586	94	531,804	152,740	(b)	(b)	12,361	(b)	8,687
1904..	6,530	6,182	117	422,159	108,319	(b)	(b)	15,186	(b)	13,500
1905..	8,900	6,972	57	465,622	89,687	(b)	(b)	13,729	(b)	11,757
1906..	11,530	7,718	85	680,620	96,382	(b)	(b)	12,308	(b)	11,582
1907..	11,730	10,652	105	768,863	92,970	(b)	(b)	13,814	(b)	11,719
1908..	4,350	7,471	61	531,368	65,757	(b)	(b)	15,892	(b)	8,786
1909..	9,600	8,193	208	475,616	54,926	(b)	(c)	14,948	(b)	3,873
1910..	9,450	12,939	243	535,482	50,015	(c)	8,355	16,710	(b)	1,500
1911..	12,915	10,544	1,263	496,731	27,482	.....	182,324	14,283	.....	.....
1912..	6,468	3,359	127	376,931	12,212	.....	175,463	14,489	.....	.....

Year.	Magnesite.			Manganese Ore.	Pozzolan.	Sea Salt.	Sulphur.	Zinc Ore.	
	Crude.	Bricks.	Calcined.					Blende.	Calamine, Calcined.
1899....	17,184	542	3,087	17,600	46,375	37,125	1,150	1,137	21,770
1900....	17,277	534	807	8,050	49,426	22,411	891	(b)	18,751
1901....	20,348	500	2,009	14,166	80,169	23,079	3,212	454	17,764
1902....	23,020	935	4,730	14,960	32,514	25,200	1,391	(b)	18,670
1903....	28,415	(b)	(b)	9,340	40,978	26,000	1,266	(b)	12,350
1904....	9,133	(b)	(b)	8,549	44,644	27,000	1,225	(b)	19,913
1905....	37,063	(b)	(b)	8,171	41,900	25,201	1,126	(b)	22,562
1906....	40,584	(b)	(b)	10,040	30,622	25,167	(b)	(b)	26,258
1907....	55,816	(b)	(b)	11,139	39,637	26,966	(b)	(b)	30,346
1908....	63,079	(b)	(b)	10,750	52,312	23,988	(b)	28,739	24,101
1909....	56,797	294	16,609	5,374	46,238	29,448	(b)	41,656	30,159
1910....	18,073	295	19,932	41	31,609	25,978	(b)	(f)5,845	28,898
1911....	86,956	275	27,530	.....	.....	26,952	(h)35,956	35,856	30,512
1912....	106,338	496	33,848	.....	.....	31,400	(h)31,811	39,585	28,912

(a) Statistics up to 1903 communicated by E. Grohmann, Seriphos. Statistics for 1903 and subsequent years from *Statistique du Mouvement Minier de Grèce*. The figures represent sales or shipments. (b) Not reported. (c) No sales, but production of lead ore is reported at 240,013 tons in 1909 and 185,207 tons in 1910. (d) Contains 9 per cent. lead and 11 per cent. zinc. (f) Production in 1910 was 37,108 tons. (g) sales. (h) pyrite.

INDIA

The official statistics of mine al production in British India are summarized in the subjoined table. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF INDIA. (a)

(In metric tons or dollars; £1 = $5.)

Year.	Amber.	Coal.	Chromite.	Diamonds Carats.	Gold. (c)	Graphite.	Iron Ore.	Jade. (e) Cwt.	Magnesite.
1899...	755	5,174,752	.....	.....	8,357,087	1,548	(d)52,832	228	(b)
1900...	515	6,222,591	.....	.....	9,205,518	1,859	(d)57,912	142	(b)
1901...	55	6,741,899	.....	.....	9,394,723	2,530	(d)58,725	206	(b)
1902...	2,160	7,543,272	.....	.....	9,611,985	4,648	(d)77,273	174	3,597
1903...	2,070	7,557,400	248	.....	11,203,926	3,448	(d)62,337	99	838
1904...	4,190	8,348,561	3,596	286.5	11,513,340	2,955	72,757	130	1,193
1905...	4,725	8,552,422	2,708	172.4	11,760,957	2,361	104,174	106	2,645
1906...	3,545	9,939,782	4,375	305.9	10,852,546	2,642	75,295	116	1,861
1907...	1,925	11,326,254	18,597	268.0	10,348,795	2,472	68,928	2,636	189
1908...	1,820	12,974,588	4,821	140.8	10,597,404	2,919	60,175	3,211	7,655
1909...	1,435	12,060,580	9,398	147.8	10,728,900	3,132	84,791	2,487	749
1910...	1,415	12,240,775	1,765	77.7	10,717,300	4,319	55,499	1,908	5,285
1911...	665	12,715,534	2,865	53.0	10,890,804	4,047	366,212	2,063	3,546
1912....	895	14,706,339	2,936	27.8	11,054,608	*Nil*	580,029	806	15,626

Year.	Manganese Ore.	Mica.	Petroleum *Gallons.*	Rubies. *Carats*	Salt.	Saltpeter (Potassium Nitrate.)	Tin Ore.
1899....	88,524	497	32,934,007	454,240	977,269	18,555	64
1900....	129,865	1,025	37,729,211	486,630	1,071,877	20,189	94
1901....	122,831	1,505	50,075,117	522,380	1,208,933	17,711	63
1902....	160,311	806	56,607,688	434,475	1,116,797	17,320	91
1903....	174,563	1,002	87,859,069	444,095	1,021,581	18,711	100
1904....	152,601	828	118,491,382	453,060	1,319,535	14,200	63
1905....	250,788	1,172	144,798,444	.....	1,426,066	15,745	68
1906....	579,231	2,458	140,553,122	465,115	1,371,172	16,822	87
1907....	916,770	2,652	152,045,677	491,290	1,120,453	18,664	77
1908....	685,135	2,720	176,646,320	239,770	1,390,153	19,620	96
1909....	652,958	1,672	233,678,087	293,200	1,275,688	20,953	86
1910....	813,721	1,153	214,829,647	294,245	1,720,194	16,140	90
1911....	670,290	1,700	225,792,094	288,213	1,325,882	14,679	97
1912....	637,444	2,196	249,083,518	323,245	1,454,602	14,797	175

(a) Records of the Geological Survey of India. (b) Not reported. (c) £1 = $4.866. (d) Production of iron ore in Bengal only. (e) Exports in cwt. of 112 lb.

ITALY

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY. (a)
(In metric tons or dollars; 5 lire = $1.)

Year.	Alum.	Aluminium Sulphate.	Alunite.	Antimony.	Antimony Ore.	Asphalt, Mastic and Bitumen.	Asphaltic Rock.	Barytes.
1898.....	1,165	2,915	7,000	380	1,931	17,813	93,750	12,400
1899.....	945	2,330	5,800	581	3,791	41,732	81,987	12,545
1900.....	1,097	2,403	5,200	1,174	7,609	33,127	101,738	14,003
1901.....	1,075	2,260	4,900	1,721	8,818	31,814	104,111	13,245
1902.....	.....	.....	8,200	1,574	6,116	33,684	64,245	.....
1903.....	.....	.....	8,100	905	6,927	35,757	89,078	.....
1904.....	2,490	2,210	8,000	836	5,712	34,227	111,390	250
1905.....	2,975	2,740	8,500	327	5,083	26,838	106,586	590
1906.....	2,878	2,800	7,500	537	5,704	34,386	130,225	800
1907.....	3,175	3,010	7,600	610	7,892	38,568	161,126	1,720
1908.....	2,875	2,100	6,165	345	2,821	34,761	134,163	1,895
1909.....	2,580	2,750	5,636	59	1,077	39,165	111,067	1,950
1910.....	2,510	2,773	6,081	*Nil*	2,194	41,705	162,212	14,420
1911.....	2,725	2,493	6,100	*Nil*	2,441	50,179	188,133	13,620
1912.....	.....	.....	6,002	*Nil*	1,878	.....	181,397	.....

Year.	Borax, Refined.	Boric Acid.		Coal. (c)	Coal. (Briquettes.)	Coke.	Copper.		
		Crude.	Refined.				Ore.	Ingot, etc.	Sulphate.
1898...	702	2,650	166	341,327	594,500	469,228	95,128	3,230	6,364
1899...	709	2,674	129	388,534	566,000	485,951	94,764	3,032	7,795
1900...	858	2,491	283	479,896	703,740	487,831	95,644	2,797	13,191
1901...	544	2,558	347	425,614	754,800	490,803	107,750	3,097	15,374
1902...	.....	2,763	.....	414,569	.....	.....	101,142	.....	14,601
1903...	.....	2,583	.....	346,887	724,993	554,559	114,823	.....	18,164
1904...	569	2,624	314	362,151	903,610	607,297	157,503	2,313	17,237
1905...	1,007	2,700	749	412,916	842,250	627,984	149,035	1,175	26,212
1906...	1,062	2,561	562	473,293	829,277	672,689	147,137	.....	34,270
1907...	880	2,305	466	453,137	787,087	717,704	167,619	17,491	45,263
1908...	1,024	2,520	429	480,029	822,699	813,842	106,629	18,280	42,598
1909...	1,110	2,431	578	555,073	924,479	999,381	90,272	20,005	28,551
1910...	912	2,502	695	562,154	918,055	1,160,543	68,369	22,467	36,236
1911...	738	2,648	444	555,137	794,206	363,493	68,136	22,908	44,626
1912...	.....	2,309	.....	663,812	876,565	437,706	86,001	26,659	52,311

Year.	Gold.		Graphite.	Iron and Steel.				
	Ore.	Bullion.		Ore.	Pig.	Bar, sheet, Pipe, Wire, etc.	Tin Plate.	Steel.
1898.....	9,549	$ 124,869	6,435	190,110	12,387	167,499	7,200	87,467
1899.....	11,859	75,294	9,990	236,549	19,218	197,730	8,000	108,501
1900.....	5,840	38,212	9,720	247,278	23,990	190,518	10,000	115,887
1901.....	890	2,725	10,313	232,299	15,819	180,729	7,550	123,310
1902.....	1,215	.....	9,210	240,705	.....	.....	.....	.....
1903.....	5,734	41,933	7,920	374,790	90,744	177,392	11,275	154,134
1904.....	6,746	43,063	9,765	409,460	112,598	181,385	16,655	177,086
1905.....	1,200	9,169	10,572	366,616	181,248	205,915	18,560	244,793
1906.....	6,543	47,321	10,805	384,217	180,940	236,946	16,350	332,924
1907.....	13,475	33,582	10,989	517,952	148,996	248,157	24,423	346,749
1908.....	14,671	39,930	12,914	539,120	158,100	302,509	28,277	437,674
1909.....	2,890	6,562	11,583	505,095	254,904	281,098	35,880	608,795
1910.....	2,147	10,047	12,510	551,259	399,700	311,210	42,670	670,983
1911.....	2,080	36,550	12,621	373,786	302,931	303,223	25,662	697,958
1912.....	2,366	21,930	13,170	582,066	379,989	179,516	28,916	801,907

Year.	Lead.		Manganese Ore.	Manganiferous Iron Ore.	Marble.	Petroleum. Crude.	Refined Petroleum, Benzene, etc.	Pumice-Stone.
	Ore.	Pig.						
1898.....	33,930	24,543	3,002	11,150	271,725	2,015	5,040	2,766
1899.....	31,046	20,543	4,356	29,874	313,744	2,242	5,384	7,300
1900.....	35,103	23,763	6,014	26,800	310,336	1,683	6,077	7,000
1901.....	43,449	25,796	2,181	24,290	334,146	2,246	4,211	8,300
1902.....	42,330	26,494	2,477	23,113	.....	2,633	.....	.....
1903.....	42,443	22,126	1,930	4,735	.....	2,486	4,577	.....
1904.....	42,846	23,475	2,836	2,836	390,118	3,543	6,388	11,600
1905.....	39,030	19,077	5,384	5,384	389,869	6,122	9,924	11,200
1906.....	40,945	21,268	3,060	20,500	430,202	7,452	10,954	16,366
1907.....	(d)43,037	22,978	3,654	18,874	434,612	8,326	10,556	11,500
1908.....	46,649	26,003	2,750	17,812	425,600	7,088	10,876	15,000
1909.....	37,945	22,133	4,700	25,830	391,295	5,895	11,077	10,000
1910.....	36,840	14,495	4,200	25,700	427,274	7,069	12,149	12,900
1911.....	39,008	16,684	3,515	6,482	429,347	10,390	15,569	16,430
1912.....	41,680	21,450	2,641	.....	447,584	7,479	13,792	.....

Year.	Pyrite. (Cupriferous in part.)	Quicksilver.		Salt.			Silver.	
		Ore.	Metal.	Brine.	Rock.	Sea.	Ore.	Bullion. *Kg.*
1898.....	67,191	19,201	173	11,546	18,199	451,426	435	43,437
1899.....	76,538	29,322	205	11,021	18,721	363,826	540	33,645
1900.....	71,616	33,930	260	10,890	18,331	338,034	584	31,169
1901.....	89,376	38,614	278	10,690	23,054	401,443	511	32,464
1902.....	93,177	44,261	.....	10,581	23,677	424,239	421	.....
1903.....	101,455	55,528	312	10,962	25,911	451,633	405	24,388
1904.....	112,004	60,403	352	11,878	18,638	433,810	143	24,943
1905.....	117,667	63,378	369	12,756	19,669	405,274	170	20,215
1906.....	122,364	80,638	417	13,751	19,007	496,872	48	20,262
1907.....	126,925	76,561	434	19,238	31,540	454,454	62	20,502
1908.....	131,721	82,534	684	15,180	24,033	473,857	53	20,746
1909.....	149,084	97,592	771	15,081	28,026	421,362	44	20,534
1910.....	165,688	87,129	894	16,600	39,197	447,440	32	14,237
1911.....	165,273	97,803	955	17,251	43,763	460,439	24	12,143
1912.....	277,585	88,200	1,000	18,775	39,954	466,220	27	14,363

Year.	Sulphur.			Talc. Ground.	Zinc.	
	Crude (Fused).	Ground.	Refined.		Ore.	Spelter.
1898.....	502,351	146,001	99,494	12,760	132,099	250
1899.....	563,697	161,509	110,213	11,000	150,629	251
1900.....	544,119	167,466	157,957	14,415	139,679	547
1901.....	563,096	171,252	141,431	11,770	135,784	511
1902.....	510,333	.....	.....	.....	131,965	.....
1903.....	553,751	139,376	139,464	6,300	157,521	126
1904.....	527,563	189,266	163,695	6,740	148,365	180
1905.....	568,927	180,676	180,774	6,626	147,834	5
1906.....	499,814	176,476	170,990	7,894	155,751	69
1907.....	426,972	151,338	160,617	8,850	160,517	188
1908.....	445,312	160,093	156,995	9,410	(e)152,254	(b)
1909.....	435,060	132,531	144,579	9,530	(g)130,890	(b)
1910.....	(i)430,366	171,570	169,093	11,590	(g)146,307	(b)
1911.....	414,161	158,977	166,802	14,156	139,719	(b)
1912.....	389,451	164,864	168,514	.....	149,776	.....

(a) From *Rivista del Servizio Minerario*. (b) Not reported. (c) Includes anthracite, lignite, fossil wood and bituminous schist. (d) Does not include 680 tons lead and zinc ore. (e) Includes 560 tons lead-zinc ore. (g) Includes 290 and 300 tons lead-zinc ore,. 1909 and 1910. (h) Includes 19,460 from foreign ores. (i) Besides 21,297 tons ore sold. Natural. (j) Ground.

MINERAL IMPORTS OF ITALY. (a)

(In metric tons or dollars; 5 lire = $1.)

Year.	Antimony.	Arsenic. Kg.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.
1899.....	64	600	1,675	1,473	936	123	14,391	13,738
1900.....	37	900	1,645	1,933	859	122	15,494	18,436
1901.....	49	1,800	2,019	1,450	825	232	14,872	20,731
1902.....	80	1,200	1,536	1,020	1,170	516	13,732	15,216
1903.....	98	4,400	1,691	1,567	1,099	504	15,547	10,063
1904.....	131	3,700	2,174	2,604	1,875	271	15,260	6,891
1905.....	117	3,400	1,806	3,252	1,444	112	15,797	5,556
1906.....	50	5,300	2,171	2,854	1,400	163	18,937	7,714
1907.....	163	3,100	3,110	3,661	1,540	307	29,024	6,156
1908.....	153	2,800	2,548	3,730	1,523	333	28,935	7,210
1909.....	293	4,800	2,285	3,826	2,094	386	25,250	11,120
1910.....	342	5,300	2,051	3,365	1,777	363	22,183	9,007
1911.....	358	5,500	3,892	4,238	2,024	741	24,467	7,942
1912.....	636	4,600	4,080	3,548	1,986	380	23,423	6,809
1913.....	513	2,500	4,750	4,300	1,761	159	19,950	5,501

Year.	Coal.	Copper Ore.	Copper. Cement.	Copper, Brass and Bronze.	Copper and Iron Sulphates.	Gold. Kg.	Graphite.
1898.....	4,431,524	5,471	2,040	7,433	25,560	507	382
1899.....	4,859,556	2,777	1,328	7,334	27,408	326	608
1900.....	4,947,180	5,290	1,298	9,249	32,127	309	982
1901.....	4,838,994	11,047	1,987	8,659	32,058	494	102
1902.....	5,406,069	9,422	2,299	10,865	25,107	479	60
1903.....	5,546,823	9,459	649	9,588	24,566	1,396	63
1904.....	5,904,578	8,104	309	15,198	37,298	1,961	52
1905.....	6,437,539	6,879	486	18,188	30,684	5,768	107
1906.....	7,673,435	9,363	802	21,458	25,060	4,571	361
1907.....	8,300,439	18,023	888	28,937	15,939	4,443	267
1908.....	8,452,320	14,784	344	28,025	25,037	(d)8,367	383
1909.....	9,303,506	11,303	630	22,391	9,137	(d)8,311	141
1910.....	9,338,752	7,550	456	30,339	13,599	(d)13,188	229
1911.....	9,595,882	6,607	277	38,650	37,929	(d)12,712	246
1912.....	10,057,228	6,253	578	43,729	36,602	(d)10,545	403
1913.....	10,810,860	737	352	39,433	30,472	(d) 9,940	567

Year.	Iron.		Iron and Steel Scrap.	Lead.		Lead Oxide and Carbonate.	Mineral Paints.
	Ore.	Pig.		Ore. (c)	Metal and Alloys in Pigs.		
1898.....	8,723	169,059	138,426	10,947	1,431	647	692
1899.....	20,799	191,613	245,616	7,476	3,990	662	958
1900.....	19,205	160,686	197,415	9,134	3,248	557	958
1901.....	4,054	159,972	148,305	9,063	2,926	815	865
1902.....	4,314	155,143	198,914	1,680	7,563	846	670
1903.....	5,937	126,756	206,036	689	5,398	768	859
1904.....	4,390	149,130	246,359	2,187	4,541	871	940
1905.....	4,745	136,077	276,311	465	6,764	686	974
1906.....	6,452	168,985	344,977	4,526	10,958	984	964
1907.....	22,046	231,042	362,567	4,342	9,231	953	1,119
1908.....	31,090	254,239	326,119	5,620	11,742	1,474	2,616
1909.....	28,150	246,730	416,354	3,003	10,011	1,132	1,713
1910.....	17,673	204,854	386,604	1,426	14,674	1,225	1,775
1911.....	50,554	234,770	392,703	6,042	20,187	1,077	1,756
1912.....	18,606	267,355	343,728	12,391	15,627	914	1,962
1913.....	7,666	221,697	326,136	9,552	11,494	682	2,410

Year.	Nickel Alloys and Manufactures.	Petroleum.	Phosphate Rock.	Potash, Ammonia and Caustic Soda.	Potassium Sulphate.	Quicksilver.	Silver, *Kg.*	Slag, Metalliferous
1899.....	250	71,391	116,283	12,370	1,297	62	1,782	56,549
1900.....	232	73,089	140,281	14,077	1,670	49	2,678	32,254
1901.....	476	69,298	142,108	14,693	1,411	36	4,391	7,312
1902.....	561	68,781	159,341	17,617	1,566	57	8,768	5,634
1903.....	525	68,220	172,328	17,528	1,353	28	12,541	8,849
1904.....	652	69,233	217,162	14,846	1,663	25	15,885	3,821
1905.....	574	66,493	240,144	17,752	1,804	57	20,697	72,785
1906.....	717	64,541	307,762	16,718	1,534	12	20,410	88,118
1907.....	725	72,715	384,896	15,225	3,866	11	21,529	5,378
1908.....	1,079	82,373	531,921	14,962	4,891	10	(*d*)83,434	1,123
1909.....	540	88,929	478,199	15,547	5,333	2.2	(*d*)47,234	878
1910.....	1,311	84,748	422,714	16,983	7,753	2.5	(*d*)55,516	3,153
1911.....	1,584	119,245	479,042	16,312	9,493	2.0	(*d*)52,576	95
1912.....	1,742	113,231	466,144	17,816	13,466	1.5	(*d*)79,763	164
1913.....	1,173	115,381	529,776	17'510	9,839	0.3	(*d*)87,856	2,560

Year.	Sodium Salts.		Sod. and Pot. Nitrates, Refined.	Tin.		Zinc.			
	Carbonate.	Nitrate (Crude).		Block.	Mnfres.	Ore.	Oxide.	Spelter and Old.	Mnfres.
1898....	20,845	19,961	702	1,722	109	216	573	2,813	3,200
1899....	22,654	22,385	671	1,240	96	(*b*)	804	3,498	3,221
1900....	23,215	27,706	511	1,643	56	85	1,034	3,627	3,543
1901....	21,956	40,498	315	1,858	91	23	813	3,991	4,079
1902....	26,133	24 483	314	2,114	110	131	904	3,805	4,167
1903....	24,753	43,480	638	2,288	130	46	1,416	4,551	4,461
1904....	27,747	32,283	613	2,170	150	362	1,124	5,202	4,168
1905....	29,066	46,517	689	2,304	103	14	1,246	5,997	4,701
1906....	31,170	32,508	395	3,361	167	2,042	1,920	6,835	4,421
1907....	35,538	41,457	668	2,771	183	11	1,962	8,152	5,407
1908....	38,268	60,784	428	2,602	187	7	2,026	9,339	5,112
1909....	38,252	43,658	532	2,555	191	13	1,571	9,222	4,572
1910....	45,174	61,192	1,083	2,760	238	18	2,001	8,971	5,416
1911....	45,596	59,561	417	2,524	211	428	2,100	10,742	5,892
1912....	49,284	54,634	529	2,626	157	*Nil.*	2,550	11,955	5,823
1913....	52,332	67.418	574	3,068	144	5	2,983	12,448	6,071

MINERAL EXPORTS OF ITALY. (*a*)

(In metric tons or dollars; 5 lire = $1.)

Year.	Antimony.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.	Coal.
1899.....	240	245	26,402	45	2,872	5,462	5,386	20,803
1900.....	467	261	24,287	40	2,114	6,860	2,980	23,926
1901.....	765	302	21,856	32	2,190	8,463	3,428	25,594
1902.....	359	144	20,884	91	1,847	7,930	4,215	33,374
1903.....	314	222	24,303	35	901	6,325	3,802	29,219
1904.....	107	163	14,880	70	1,122	7,810	4,089	35,149
1905.....	132	236	23,740	162	2,255	8,445	5,007	38,555
1906.....	206	205	27,176	147	2,777	6,774	4,194	31,686
1907.....	115	142	26,036	152	1,330	4,477	3,118	40,769
1908.....	10	193	24,158	724	1,005	5,439	3,224	48,774
1909.....	8	527	21,978	125	1,704	7,534	2,533	51,343
1910.....	2	485	26,125	150	1,536	7,131	3,525	48,144
1911.....	*Nil.*	517	28,455	353	1,347	10,742	5,764	40,800
1912.....	11	571	13,158	381	1,661	55,091	9,440	26,298
1913.....	.....	672	6,596	234	1,373	56,448	6,736	19,200

Year.	Copper. Ore.	Copper and Iron Sulphate.	Gold. *Kg.*	Graphite.	Iron.		
					Ore.	Pig.	Scrap.
1898.....	2,356	25	1,739	5,145	217,556	840	.....
1899.....	1,148	20	1,162	8,114	234,515	378	.....
1900.....	1,179	60	2,763	7,820	170,286	329	.....
1901.....	9	20	2,955	7,169	121,592	311	.....
1902.....	11	39	733	7,098	209,070	395	.....
1903.....	15	44	1,291	7,068	98,319	810	.....
1904.....	43	29	1,494	7,433	2,577	229	.....
1905.....	77	249	1,731	6,811	11,358	1,395	.....
1906.....	189	102	1,476	4,904	1,833	254	.....
1907.....	179	835	802	7,474	26,000	121	.....
1908.....	188	721	7,588	7,009	35,653	176	1,676
1909.....	233	1,211	15,452	8,125	46	209	1,480
1910.....	969	741	16,643	7,647	9,892	327	2,450
1911.....	130	157	14,144	7,633	22,851	290	3,390
1912.....	267	1,445	13,993	7,785	12,313	51	5,662
1913.....	285	609	16,440	8,329	9,700	555	6,909

Year.	Lead.			Mineral Paints.	Phosphate Rock.	Quicksilver.	Salt.	Silver, *Kg.*
	Ore.	Lead Alloys in Pigs.	Oxide and Carbonate.					
1898.....	4,492	5,870	414	2,884	(*b*)	244	126,860	68,607
1899.....	3,129	2,497	389	2,784	(*b*)	223	114,050	32,432
1900.....	3,741	5,018	367	2,977	1,726	259	112,900	25,310
1901.....	3,977	4,463	410	2,913	1,290	301	114,210	42,325
1902.....	3,354	5,650	404	2,953	894	215	145,190	20,427
1903.....	5,041	2,911	426	3,305	2,942	222	144,910	9,486
1904.....	5,524	1,954	347	3,231	2,812	266	130,940	24,165
1905.....	4,311	976	310	3,632	3,519	243	116,040	25,947
1906.....	8,356	2,005	315	4,502	1,652	278	126,199	18,262
1907.....	3,213	1,548	240	4,602	4,560	350	99,191	18,164
1908.....	2,041	1,243	219	3,446	2,271	565	85,489	(*d*)28,716
1909.....	1,037	782	211	4,310	2,979	714	103,895	(*d*)87,653
1910.....	4,122	933	197	3,945	3,627	781	122,404	(*d*)22,403
1911.....	15,791	637	196	4,182	5,427	1,037	119,173	(*d*)28,434
1912....	17,062	4,122	75	4,417	1,285	993	155,543	(*d*)27,275
1913....	16,950	577	304	4,116	4,171	993	161,118	179,322

Year.	Slag.	Sodium Salts.			Sulphur.	Tin.		Zinc.		
		Carbonate	Nitrate. (Crude.)	Sod. and Pot. Nitrates, Refined.		Block.	Manufactures	Ore.	Oxide.	Spelter and Scrap.
1898....	6,861	391	79	256	405,823	34	177	130,064	110	156
1899....	4,898	438	136	124	424,018	69	176	140,107	123	227
1900....	4,222	486	58	129	479,139	147	153	111,870	102	359
1901....	3,261	377	116	59	414,018	202	187	103,020	140	349
1902....	3,615	446	346	259	439,242	236	174	114,894	122	338
1903....	4,929	482	781	492	461,289	173	180	116,449	116	591
1904....	4,458	376	363	230	437,067	171	151	126,393	483	263
1905....	9,844	214	424	159	381,128	285	107	117,810	173	434
1906....	8,990	253	80	133	336,339	303	81	144,244	687	639
1907....	10,934	200	138	102	297,378	434	117	142,271	727	1,182
1908....	12,122	583	37	57	330,093	180	173	122,456	395	984
1909....	17,163	517	464	163	329,233	85	126	123,936	212	983
1910....	10,488	321	98	45	344,513	164	245	127,315	957	845
1911....	8,274	180	168	15	398,592	166	319	133,471	1,577	616
1912....	19,563	243	27	7	376,387	83	359	152,840	2,165	1,222
1913....	8,251	337	50	11	351,339	152	394	144,644	1,313	1,566

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore. (*d*) Includes coin, bullion, sheets, and leaf.

JAPAN

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF JAPAN. (a).

Year.	Antimony.		Arsenic. *Kg.*	Coal.	Copper.	Gold. *Kg.*	Graphite.	Iron. Pig.	Lead.
	Ore.	Metal.							
1898....	1,005	235	7,129	6,643,047	21,023	1,159	347	23,611	1,703
1899....	712	229	5,077	6,668,608	19,421	1,675	53	23,066	1,963
1900....	81	349	4,669	7,370,667	24,317	2,124	94	24,841	1,878
1901....	118	429	10,312	8,884,812	27,392	2,475	88	29,449	1,803
1902....	88	528	12,188	9,588,910	29,034	2,975	97	32,130	1,644
1903....	153	434	6,000	10,088,845	33,245	3,140	114	33,870	1,728
1904....	104	321	4,000	10,723,796	33,187	2,765	216	38,143	1,803
1905....	96	190	8,333	11,955,946	35,944	3,048	209	53,210	2,272
1906....	97	627	5,250	13,468,529	36,963	2,873	177	57,373	4,305
1907....	(b)	248	7,491	13,764,731	40,183	2,938	103	44,447	3,079
1908....	(b)	198	19,838	14,767,638	41,399	3,598	177	42,007	2,910
1909(d)	10	157	8,061	14,810,412	45,117	3,932	121	46,627	3,337
1910(d)	8	120	11,463	15,433,621	48,545	4,368	145	58,043	3,845
1911....	.....	97	5,760	17,632,710	53,401	4,690	114	63,986	4,125
1912....	.....	80	.....	19,515,285	62,939	5,233	149	56,265	3,764
1913...	.....	.....	.....	.....	73,200	6,727	.....	.....	.....

Year.	Manganese. Ore.	Petroleum. *Gallons.*	Phosphates.	Pyrite.	Quicksilver. *Kg.*	Salt. *Hectoliters.*	Silver. *Kg.*	Sulphur.	Tin.
1897....	15,448	9,179,474	(b)	7,626	2,678	(b)	54,289	13,582	47.6
1898....	11,497	11,145,457	(b)	8,726	1,399	11,482,422	60,436	10,321	42.7
1899....	11,336	18,844,034	(b)	8,376	.....	10,483,082	56,161	10,237	18.5
1900....	15,831	30,470,068	(b)	16,166	270	11,890,361	58,799	14,439	12.3
1901....	16,270	39,056,820	(b)	17,589	750	12,463,771	54,739	16,548	14.1
1902....	10,844	34,850,129	196	18,580	1,418	11,042,192	57,635	18,287	18.6
1903....	5,616	50,724,174	191	16,149	206	6,574,890	58,704	22,914	19.0
1904....	4,324	51,573,754	13	24,886	*Nil.*	7,019,650	61,339	25,587	25.0
1905....	14,017	47,132,800	1,519	25,569	349	(b)	82,886	24,652	26.0
1906....	54,339	60,005,957	3,037	36,038	336	(b)	76,247	27,589	77.0
1907....	20,586	60,110,558	1,721	56,166	456	(f)636,168	95,600	33,329	31.8
1908(d)	11,130	65,165,860	740	33,867	804	(f)659,202	123,180	33,149	25.7
1909(d)	8,708	65,789,858	3,781	27,066	335	(f)696,049	127,917	36,317	22.8
1910....	11,120	63,843,601	1,042	78,418	407	(f)696,474	141,613	43,155	23.
1911....	9,787	72,839,260	2,271	73,879	1,021	(g)567,715	138,287	50,274	24.8
1912....	12,060	67,557,322	7,847	74,929	27	.....	152,385	55,005	35.6

(a) From *Résumé Statistique de l'Empire du Japon*, Tokio. (b) Not reported. (c) Crude petroleum. (d) From reports of the Japanese Department of Agriculture and Commerce. (e) 328 tons of ore reported, in addition. (f) Metric tons including Taiwan, fiscal years. (g) Metric tons; from *Résumé Statistique de l'Empire du Japan.*

MEXICO

Owing to the incompleteness of the Mexican statistics of production, we are unable to give any satisfactory table. Exports may, however, be taken as indicating the condition of the mining industry. We owe the statistics for 1908, 1909 and 1910 together with a complete revision of this table, to the courtesy of Don Miguel M. Irigoyen, chief of the Section of Statistics, Secretaria de Hacienda y Credito Publico.

MINERAL EXPORTS OF MEXICO. (a)
(In metric tons or Mexican dollars.)

Year.	Antimony.		Coal.	Copper.		Gold.				
	Metal.	Ore.		Ore.	Ingot.	Ore.	Bullion.	Specie.	Cyanide.	Sulphide.
1898...	.....	5,932	118,553	13,146	10,362	$1,037,202	$6,493,735	$367,704	$294,730	$64,061
1899...	.....	10,382	113,192	223	25,293	335,849	7,017,286	183,474	115,961	266,782
1900...	.....	2,313	38,676	408	27,970	306,392	7,435,884	192,456	128,675	177,193
1901...	.....	5,103	17,281	5,576	33,818	284,722	8,324,631	210,431	178,803	81,744
1902...	1,218	1,280	3,406	6,101	63,609	303,979	9,079,371	129,899	78,295	40,658
1903...	2,304	7,302	1,840	10,912	51,716	264,503	9,693,692	54,036	85,465	124,020
1904...	1,694	81	125	48,365	57,338	537,290	10,867,272	172,532	79,129	176,090
1905 (c)	1,978	57	497	92,540	56,634	1,513,344	29,636,117	106,470	397,814	138,033
1906...	2,418	178	91	73,193	46,767	5,369,173	21,072,014	37,746	337,294	180,348
1907...	4,615	681	1,532	115,245	51,519	3,033,090	19,653,362	5,023,404	417,162	497,893
1908...	4,046	36	719	70,900	26,214	2,746,289	30,101,546	42,389	144,959	334,944
1909...	4,115	31	235	136,031	32,580	2,346,279	40,725,976	23,678	85,110	250,741
1910...	3,730	6	120	129,588	54,061	2,526,444	46,189,613	37,723	46,803	168,162
1911...	4,131	121	101	109,627	60,493	1,945,660	48,113,427	8,153,293	38,031	141,640
1912...	3,491	15	50,777	103,129	60,439	1,121,333	42,686,667	1,479,292	43,481	119,357
1913...	2,340	(b)	40	19,500	29,438	785,531	32,918,172	470,758	54,417	172,188

Year.	Graphite.	Gypsum.	Lead.		Silver.					
			Ore.	Base Bullion.	Ore.	Bullion.	Specie.	Sulphide.	Cyanide.	Slag.
1898...	1,365	1,650	(b)	60,918	$11,048,358	$37,137,599	$16,588,789	$1,663,501	$257,342	$46,488
1899...	2,305	1,050	1	67,441	10,766,099	37,585,911	5,580,834	1,929,085	76,942	4,819
1900...	2,561	1,600	468	74,944	12,495,524	41,468,745	22,679,655	1,893,646	67,607	87,880
1901...	762	800	(b)	79,097	9,615,939	36,348,374	12,038,158	2,141,685	259,232	93,543
1902...	1,434	(b)	118	107,366	4,108,088	45,796,576	17,753,526	1,978,919	108,344	132,093
1903...	1,404	(b)	11	100,532	11,781,048	48,276,797	16,167,673	1,642,627	135,561	289,900
1904...	970	(b)	1	95,010	11,000,869	45,430,020	7,251,132	1,392,356	171,452	202,594
1905 (c)	970	27	1	101,196	8,505,834	63,564,789	20,335,297	736,228	438,094	29,012
1906...	3,915	(b)	(b)	73,699	9,619,783	63,057,152	42,390,357	595,112	434,885	(b)
1907...	3,202	(b)	11	76,158	11,396,844	68,187,169	23,848,571	785,116	483,638	(b)
1908...	1,076	(b)	26	127,010	11,230,372	63,298,659	60,405	791,698	68,849	(b)
1909...	1,704	(b)	1	118,186	8,057,189	66,789,716	91,006	557,520	78,688	(b)
1910...	2,332	1	355	120,662	6,793,896	70,272,894	72,891	208,300	52,053	(b)
1911...	2,974	(b)	397	124,605	6,766,644	78,515,378	8,901	235,410	159,170	*None*
1912...	2,865	(b)	59	109,717	5,769,575	82,047,500	8,645	(d)	347,277	*None*
1913...	1,057	(b)	1,386	55,530	2,108,805	63,232,843	2,585,701	423,625	418,522	(b)

(a) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. (b) Not reported. (c) Figures for 1904 are from *Anuario Estadistico de la República Mexicana* for 1904. (d) 11 metric tons.

NORWAY

The official statistics of mineral production, imports and exports, are summarized in the following tables: Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF NORWAY. (a)

(In metric tons or dollars; 1 Krone = 27 cents.)

Year.	Apatite. (b)	Chrome Ore.	Copper.		Feldspar.	Gold.	Iron.		
			Ore.	Ingot.			Ore.	Pig and Cast.	Bars and Steel.
1901	738	85	40,726	1,073	18,323	$2,700	42,252	261	376
1902	2,295	22	40,499	1,347	19,591	36,990	53,675	527	461
1903	1,795	*Nil.*	35,417	1,382	18,590	8,370	53,475	509	442
1904	1,456	154	36,891	1,342	20,835	*Nil.*	45,328	350	395
1905	2,522	*Nil.*	37,045	1,153	22,508	*Nil.*	46,582	474	253
1906	3,482	*Nil.*	32,203	1,333	23,896	5,400	109,259	257	317
1907	1,830	107	39,887	1,517	32,970	*Nil.*	140,804	*Nil.*	283
1908	1,771	*Nil.*	33,688	1,806	34,437	*Nil.*	119,656	.....	.....
1909	1,364	*Nil.*	42,612	1,594	36,439	8,000	40,389	.....	.....
1910	703	.....	46,308	1,814	39,507	5,000	102,447	.....	.....
1911	897	.....	34,705	1,650	34,864	.....	220,524	316	.....
1912	1,168	115	60,018	2,130	39,844	.....	116,392	291,700	.....
1913	.....	.....	.....	**2,250**	40,843	.....	71,800	432,000	.....

Year	Molybdenite.	Nickel.		Pyrite, Iron, and Copper.	Rutile.	Silver.		Zinc Ore. (c)
		Ore.	Metal.			Ore and Native Silver.	Metal. *Kg.*	
1901	.....	2,018	13	101,894	55	519	5,680	90
1902	20	4,040	40	121,247	*Nil.*	471	6,220	30
1903	31	5,670	60	129,939	25	481	7,269	335
1904	30	5,352	75	133,603	25	1,297	8,064	42
1905	46	5,477	73	162,012	35	1,570	7,100	4,241
1906	1,026	6,081	77	197,886	55	1,565	6,370	3,308
1907	30	5,781	81	236,038	55	1,756	6,700	400
1908	35	5,190	81	269,129	83	2,262	7,470	2,435
1909	30	5,770	62	282,606	.....	2,729	7,780	983
1910	.....	19,639	69.8	329,642	116	.....	.....	2,219
1911	.....	27,743	172	369,055	76	2,892	7,635	2,240
1912	21	30,697	390	464,326	100	4,027	8,400	.....
1913	.....	**48,000**	600	**470,000**	.....	.....	.....	.....

(a) *Tabeller vedkommende Norges Bergværksdrift, Statistisk Aarbok for Kongeriket Norge.* (b) Exports which represent production. (c) Includes lead ore.

MINERAL IMPORTS OF NORWAY. (a)

(In metric tons.)

Year.	Borax. *Kg.*	Cement and Hydraulic Lime.	Coke, Coal and Cinders. *Hectoliters.*	Copper and Brass.		Iron and Steel.	
				Plates and Bars.	Wares.	Pig.	Bars, Hoops, etc. Wrought Iron.
1901.....	68,000	20,993	17,665,349	1,018	761	19,112	20,672
1902.....	(c)	18,984	19,338,615	1,118	(c)	18,969	26,685
1903.....	(c)	17,906	20,086,974	899	309	20,652	21,977
1904.....	54,953	12,845	21,049,128	688	866	18,891	24,094
1905.....	(c)	13,797	20,973,608	882	1,146	20,828	27,740
1906.....	63,000	11,676	21,478,000	906	783	20,197	26,015
1907.....	79,810	16,647	24,274,260	(f) 954	1,107	23,345	32,764
1908.....	87,255	44,991	(e)2,073,907	(f)1,013	1,157	26,106	31,849
1909	79,786	57,768	(e)2,095,611	(f) 869	1,095	23,167	31,215
1910.....	105,453	20,100	(e)2,159,717	(f)1,118	1,406	28,034	34,623
1911.....	100,493	17,892	(e)2,187,246	(f)1,229	1,780	26,569	36,172
1912.....	103,923	27,960	(e)2,474,253	(f)1,367	2,118	29,908	44,756
1913.....	107,633	31,973	(e)2,482,424	(f)1,424	.....	30,889	.....

Year.	Iron and Steel—Continued.						Lead in Pigs and Sheets.
	Anchors, Cables and Chains.	Rails.	Nails, Spikes and Screws.	Steel.	Sheets and Plates.	Other Manufactures.	
1901	1,708	22,959	1,808	1,905	31,184	18,372	590
1902	2,103	15,316	2,205	1,754	36,288	22,069	(c)
1903	1,807	4,631	1,261	1,958	42,098	18,855	311
1904	2,109	5,814	1,071	1,610	42,013	5,462	498
1905	2,224	6,566	1,222	1,436	42,203	44,414	448
1906.....	2,585	8,086	1,012	2,018	48,969	45,959	727
1907	2,653	6,989	991	1,592	47,758	48,965	887
1908	2,535	12,180	1,032	1,628	49,569	52,594	529
1909	1,750	9,051	1,049	1,911	46,195	55,198	536
1910	2,131	5,512	852	3,203	56,898	60,282	838
1911	2,327	15,312	1,129	3,908	65,847	72,170	939
1912	2,591	19,391	1,314	4,239	84,525	79,219	1,142
1913	2,479	15,126	720	31,966	76,158	.....	1,054

Year.	Lead White and Zinc Oxide.	Petroleum and Paraffin	Potash.	Salt.	Salt-peter.	Soda.	Sulphur. (b)	Tin in Blocks, etc.	Zinc in Bars, Plates, etc.
1901 ...	1,321	47,011	518	127,607	208	5,220	11,149	141	1,027
1902 ...	(c)	(c)	(c)	141,415	315	(c)	(c)	(c)	1,104
1903 ...	(c)	58,822	457	143,110	245	4,200	8,829	106	1,015
1904 ...	1,898	50,543	477	153,699	321	3,197	12,181	176	940
1905 ...	1,309	43,860	393	137,800	1,048	3,704	10,240	134	967
1906 ...	1,149	41,546	396	167,300	776	4,334	11,465	261	2,791
1907 ...	1,245	44,231	588	163,458	1,004	5,819	11,412	332	3,549
1908 ...	1,201	64,680	504	177,349	935	7,850	12,281	323	1,418
1909 ...	1,304	63,042	475	164,195	572	8,357	10,293	280	1,336
1910 ...	1,277	63,976	536	182,288	546	9,270	10,279	358	5,891
1911 ...	1,465	71,496	524	192,354	786	9,566	8,782	353	9,173
1912 ...	1,869	80,023	540	214,817	418	14,700	13,911	438	9,696
1913 ...	2,502	79,253	572	.....	522	16,918	14,607	156	1,263

MINERAL EXPORTS OF NORWAY. (a)
(In metric tons.)

Year.	Apatite.	Copper.			Feldspar.	Iodine. *Kg.*	Iron.
		Ore.	Ingot.	Scrap.			Ore.
1901	738	6,041	1,465	774	(d)18,423	10,000	39,1[illegible]
1902	2,295	4,848	1,913	(c)	(d)19,611	.....	4[illegible]
1903	1,795	3,448	1,930	888	(d)18,640	11,417	41,5[illegible]
1904	1,456	2,673	1,124	785	20,835	9,414	45,4[illegible]
1905	2,522	3,393	958	968	20,696	12,000	60,5[illegible]
1906	3,482	84	875	964	19,669	13,248	81,3[illegible]
1907	1,830	1,581	1,033	1,644	29,399	13,780	132,5[illegible]
1908	1,771	156	1,260	385	29,896	11,097	110,4[illegible]
1909	1,365	3,245	1,335	543	33,692	13,620	38,9[illegible]
1910	703	241	1,377	583	39,507	13,114	88,7[illegible]
1911	500	924	1,091	575	34,864	16,982	180,9[illegible]
1912	.....	423	1,551	366	32,844	11,642	404,9[illegible]
1913	.....	74	2,550	167	40,843	12,149	568,7[illegible]

Year.	Iron—Continued.				Nickel Ore.	Pyrite.	Silver Ore.
	Pig and Scrap.	Bars and Hoops.	Nails and Spikes.	Steel.			
1901	3,250	370	6,001	179	55	104,151	6
1902	7,359	166	6,431	240	1	105,980	*Nil.*
1903	6,350	10	6,504	200	*Nil.*	118,148	*Nil.*
1904	10,152	13	7,477	167	30	116,550	*Nil.*
1905	9,920	34	8,725	88	220	147,155	*Nil.*
1906	7,362	8	6,786	21	*Nil.*	164,119	*Nil.*
1907	4,652	7	5,879	31	11	187,983	*Nil.*
1908	6,787	2	4,839	17	*Nil.*	218,851	*Nil.*
1909	11,429	24	5,187	11	3	216,767	*Nil.*
1910	13,455	5	6,878	34	.....	343,073	*Nil.*
1911	12,569	40	5,692	271	.....	343,850	457
1912	16,889	.....	5,326	296	.....	424,121	.....
1913	.....	.....	3,972	150	3	452,750	.....

(a) From *Tabeller vedkommende Norges Bergvaerksdrift und Tabeller vedkommende Norges Handel.* (b) Includes flowers of sulphur. (c) Returns not available. (d) Includes a small quantity of fluorspar. (e) Metric tons. (f) Includes a quantity of sheet aluminium.

PORTUGAL

The subjoined table reports the mineral production of Portugal. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF PORTUGAL. (a)

(In metric tons.)

Year.	Antimony Ore.	Arsenic Ore.	Coal (Anthracite.) (c)	Copper.			
				Copper-Iron Pyrite. (e)	Other Ores.	Cement.	Matte.
1899	59	1,083	11,930	347,234	408	2,521	(b)
1900	38	1,031	24,066	402,870	(b)	2,948	(b)
1901	(b)	527	16,000	443,397	(b)	2,061	(b)
1902	68	736	11,000	413,714	655	2,205	(b)
1903	83	698	8,063	376,177	527	2,448	(b)
1904	31	1,370	12,805	383,581	297	(b)	(b)
1905	84	1,562	11,449	352,479	210	2,148	(b)
1906	481	1,322	6,762	350,746	196	3,634	(b)
1907	383	1,538	8,824	241,771	2,478	2,942	298
1908	76	1,655	4,614	81,417	15,455	3,041	564
1909	6	1,420	6,274	12,337	1,321	3,037	309
1910	25	974	8,149	19,161	230	3,768	230
1911	.....	887	10,610	15,287	517	3,979	283
1912	100	1,006	15,626	120,148	1,309	4,028	.....

Year.	Gold. Kg.	Iron Ore.	Lead Ore. (Galena)	Manganese Ore.	Sulphur Ore.	Tin Ore and Metal.	Tungsten Ore.
1899	(d) 13.0	15,078	3,468	2,949	(e)	30	55
1900	2.6	19,803	3,620	1,970	(e)	81	49
1901	2.0	21,599	445	904	(e)	31	90
1902	2.0	19,914	1,651	(b)	(e)	24	234
1903	1.3	15,200	830	30	(e)	(b)	228
1904	*Nil.*	12,488	291	(b)	(e)	51	290
1905	*Nil.*	3,200	50	(b)	(e)	20	358
1906	*Nil.*	(b)	511	22	(e)	22	570
1907	10.5	(b)	510	1,374	123,393	35	226
1908	57.0	(b)	481	(b)	24,522	28	106
1909	25.0	(b)	736	(b)	272,398	18	673
1910	4.1	3,360	919	(b)	293,745	9	948
1911	3.6	19,541	1,185	6	267,486	86	903
1912	3.5	35,210	495	6	481,295	173	1,227

(a) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mines of the Ministerio das Obras Publicas except for 1904 to 1906 inclusive, which are from official Government reports. The mineral production of the country is identical with exports except in the case of coal. (b) Not reported. (c) Consumed in the country. (d) Metric tons of ore. (e) Previous to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

RHODESIA

The statistics of the mineral production of Rhodesia for the last 12 years are given in the accompanying table.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (a).

Year.	Gold. Ozs.	Value.	Silver. Ozs.	Lead. Tons. (b)	Coal. Tons. (b)	Year.	Gold. Ozs.	Value.	Silver. Ozs.	Lead. Tons. (b)	Coal. Tons. (b)
1902...	194,170	$3,339,286	3,445	.....	.....	1908..	606,962	$12,276,394	283,424	1,069	164,114
1903...	231,872	4,022,756	20,715	.....	.....	1909..	623,388	12,985,430	262,133	965	170,893
1904...	267,737	4,711,016	70,146	455	59,678	1910..	609,956	12,657,791	217,633	749	180,068
1905...	407,048	7,046,692	89,278	570	97,191	1911..	628,521	12,991,500	187,641	639	212,529
1906...	551,894	9,647,581	110,575	652	103,803	1912..	642,807	13,174,058	176,532	587	216,140
1907 ..	612,052	10,589,385	147,324	756	115,073	1913..	689,954	14,261,343	142,390	327	243,328

(a) From report of Colonel Seely, Under-Secretary of State for the colonies. (b) Short tons.

RUSSIA

The mineral and metallurgical production of Russia, according to official statistics especially reported to THE MINERAL INDUSTRY is given in the subjoined tables. All Russian statistics are only approximate, and different authorities vary widely.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA. (a)

(In metric tons; one metric ton = 61.05 poods.)

Year.	Asbestos.	Chrome Ore.	Coal.	Copper.	Gold. (b)	Pig-iron.	Lead.	Manganese Ore.
1898..	1,665	15,466	12,307,463	7,290	$22,195,208	2,241,293	241.2	329,276
1899..	2,693	19,146	13,974,376	7,533	22,396,315	2,708,752	321.8	659,302
1900..	3,845	18,233	16,156,055	8,258	22,369,864	2,933,786	220.7	802,236
1901..	4,398	22,169	16,526,652	8,467	22,763,967	2,866,779	156.0	522,395
1902..	4,508	19,656	16,465,852	8,817	22,258,343	2,598,086	225.3	536,519
1903..	5,264	16,421	17,868,515	9,232	24,147,222	2,487,783	106.3	414,334
1904..	7,502	26,575	19,608,631	9,835	24,627,537	2,972,115	90.3	430,090
1905..	5,896	27,051	18,727,766	8,515	20,521,587	2,628,101	700.2	508,635
1906..	9,197	16,969	21,593,158	9,296	20,020,862	2,694,895	906.8	1,015,686
1907..	9,398	(g)26,357	25,741,321	15,930	26,518,253	3,041,570	520.0	(g)1,003,528
1908..	10,911	(g)10,950	(g)25,903,560	17,118	33,143,810	2,818,450	522.5	362,303
1909..	(h)13,129	22,213	24,532,349	19,656	31,889,956	2,889,353	.....	574,938
1910..	(h)10,936	1,362	(f)23,105,628	(f)22,619	(f) 35,566,045	(f)3,042,046	.....	668,050
1911..	17,071	1,238	28,007,239	(f)25,097	(f) 34,550,609	.....	.....	(i)636,180
1912..	18,138	21,277	30,641,163	33,513	28,852,831	3,726,000	.....	903,226
1913..	18,594	.....	25,772,700	34,282	22,199,000	3,801,273	.....	1,130,000

Year.	Petroleum.	Phosphate Rock.	Platinum. (Kg.)	Pyrites.	Quicksilver.	Salt.	Silver. (Kg.)	Sulphur.	Zinc.
1898..	8,009,828	1,867	6,016	24,570	362	1,505,602	5,143	1,018	5,664
1899..	8,517,608	16,863	5,962	23,250	362	1,679,726	4,419	451	6,326
1900..	9,844,390	25,663	5,089	23,154	141	1,968,007	2,293	1,587	5,963
1901..	10,925,471	21,276	6,371	30,732	363	1,705,924	1,088	2,489	6,104
1902..	10,445,536	13,709	6,135	26,465	416	1,847,021	1,200	1,800	8,264
1903..	9,759,214	14,635	6,009	22,780	362	1,658,938	1,152	281	9,894
1904..	10,058,968	20,282	5,016	31,667	332	1,908,275	726	16	10,612
1905..	7,505,637	20,585	5,250	30,689	318	1,844,678	2,965	16	7,911
1906..	8,167,934	18,970	5,776	20,660	210	1,730,934	430	39	9,602
1907..	9,098,931	(g)15,457	5,903	18,316	(g)132	1,873,171	7,843	(d)57	10,409
1908..	8,732,301	(g)14,976	4,883	56,345	147	1,879,717	9,595	(d)85	9,960
1909..	8,961,507	(h)21,326	5,120	.....	.....	2,259,690	(h)15,415	.....	7,644
1910..	8,952,793	(h)24,883	5,471	.....	.....	2,047,980	(h)14,841	.....	(f)8,631
1911..	9,152,315	(h)25,503	(f)5,432	.....	.....	2,013,765	15,512	.....	(f)9,652
1912..	9,249,600	.....	5,523	.....	.....	.....	.....	.....	.....
1913..	9,474,876	.....	5,287	.....	.....	.....	.....	.....	.....

(a) From official sources. (b) The value of gold is taken at $20.67 per ounce. (c) Not reported. (d) Includes sulphide ore. (e) Six months. (f) Statistics of Association of Russian Manufacturers and Traders. (g) St. Petersburg Scientific Committee. (h) The Russian Year Book, Dr. Kennard, London. (i) Exports.

SOUTH AMERICA

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published. Figures given in bold face are either provisional figures or estimates.

MINERAL AND METAL PRODUCTION OF BOLIVIA. (a)

(In metric tons.)

Year.	Antimony Ore.	Bismuth.		Cobalt Ore.	Copper. (c)	Gold. (b)	Silver. (d)	Tin Ore.	Tungsten Ore.
		Metal.	Ore.						
1907	2,279	249	153.379	.....	3,469	3,551	3,696	27,668	(e)500
1908	734	259	160.305	.....	3,027	21,617	156.5	29,938	170
1909	.....	89	236.762	.....	3,097	.....	155.4	35,566	170
1910	.....	97	311.060	.....	3,212	.....	143	38,548	207
1911	311.7	.....	1,208.689	.....	2,950	22,313	128.0	37,073	297
1912	91.3	(g)478	.....	.....	4,707	23,038	123.9	38,614	472
1913	.....	(g)275	.....	.....	**3,658**	**175,000**	.....	.....	.....

(a) From a British Consular report and Revista de Aduanas. (b) Reduced to U. S. currency. (c) Includes ingots, precipitate, matte and concentrate. (d) Includes ingots, ore and sulphide. (e) U. S. Geol. Surv. (f) First half of year. (g) Metal and metal content of ore.

MINERAL EXPORTS OF BRAZIL. (a)

(In metric tons or dollars.) (d)

Year.	Agate.	Carbonado.	Copper Ore.	Diamonds.	Gold.	Manganese Ore.	Mica and Talc.	Monazite.	Platinum. (Grams.)	Precious Stones. (b)	Rock Crystal.
1905	83	113,157	658	142,459	647,581	224,377	1.0	4,437	72,000	88,463	23
1906	121	319,743	1,484	340,137	771,611	121,331	$6,123	4,351	*Nil.*	141,395	37
1907	53	363,200	(c)	110,457	1,976,000	236,778	8,176	4,438	*Nil.*	33,335	37
1908(e)	79	126,380	(c)	97,090	2,187,950	166,122	5,540	4,965	*Nil.*	109,150	36
1909(e)	.....	177,572	(c)	58,862	2,252,900	240,774	.....	6,462	*Nil.*	56,338	.....
1910(e)	34	13,848	(c)	14,366	1,954,674	253,953	.....	5,437	*Nil.*	745	.....
1911(e)	112	63,400	1	103,567	2,850,370	173,941	9	371	*Nil.*	135,220	24
1912(e)	103	47,998	.....	139,175	2,676,950	154,870	11.5	3,398	*Nil.*	74,597	45
1913	.....	.....	.....	.....	**3,570,000**	.....	.....	.....	.....	.....	.....

(a) As reported by the *Brazilian Review*. (b) Other than carbonado and diamonds. (c) Statistics not available. (d) The par exchange value of the *Mil Reis* in 1907 was $0.546 U.S. gold. Common exchange value was in 1902, $4.155; in 1903, $4.134; in 1904, $4.146; in 1905, $3.153; in 1906, $3.103, and in 1907, $3.301. (e) Reported by U. S. Consul at Rio de Janeiro.

MINERAL PRODUCTION OF CHILE (a).
(In metric tons.)

Year.	Borax.	Coal.	Cobalt Ore.	Copper.	Gold. Kg.	Guano.	Iodine.	Salt.	Silver. Kg.	Sodium Nitrate.	Sulphur.
1900..	86,892	(c)	(d)	25,715	1,975	(f)	302	9,879	73,071	1,460,100	2,472
1901..	(b)	(c)	(d)	30,155	1,100	(f)	269	10,099	70,237	1,273,800	2,516
1902..		(c)	(d)	27,066	1,286	(f)	242	9,532	57,418	1,400,408	2,636
1903..	16,879	827,112	290	29,923	994	11,134	387	16,264	28,552	1,444,920	3,560
1904..	16,733	751,628	125	31,025	1,135	2,669	461	17,674	28,501	1,487,598	3,594
1905..	19,612	793,927	28	29,126	1,055	19,380	564	12,108	16,315	1,669,806	3,470
1906..	28,996	932,488	0.19	25,829	1,135	4,709	331	17,116	12,211	1,822,144	4,598
1907..	28,374	832,612	.....	28,863	1,907	7,518	4,202	18,982	18,736	1,846,036	2,905
1908..	35,039	939,836	.....	42,097	1,189	871	330	16,257	43,569	1,970,974	2,705
1909..	32,218	898,971	.....	42,726	1,268	10,692	474	20,463	35,907	2,110,961	4,508
1910..	35,192	1,074,174	.....	38,232	1,088	12,683	581	23,361	34,958	2,465,415	3,823
1911..	45,558	1,188,053	.....	36,420	.....	17,841	.....	23,720	27,675	2,521,023	4,451
1912..	43,356	1,334,407	.....	41,647	1,101	18,266	458	17,045	30,178	2,585,850	4,431
1913..	.....	.....	.....	40,042	.....	.....	437	.....	.....	.....	.....

(a) From *Estadistica Minera de Chile.* (b) The combined output of the years 1894 to 1902 inclusive. (c) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (d) The combined output of Chile up to the end of 1902 is estimated at 5941 tons. (e) Not reported. (f) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons, valued at 5,041.560 pesos ($1,840,169).

MINERAL AND METAL PRODUCTION OF PERU. (a)
(In metric tons.)

Year.	Bismuth.	Borate.	Coal. (b)	Copper.	Gold. Kg.	Lead.	Nickel. Kg.	Petroleum.	Quicksilver. Kg.	Silver. Kg.	Salt.	Sulphur.
1906...	.....	2,598	79,969	13,474	1,247.0	2,568	.....	70,832	2,304	230,300	20,226	1,830
1907...	48	2,451	185,565	20,681	777.6	5,525	.....	100,184	1,500	207,810	21,592	1,880
1908...	9	2,870	311,122	19,854	774.0	2,633	.....	125,948	1,822	195,404	21,899	.....
1909...	30	2,715	321,502	20,068	554.0	2,09g	.....	188,125	350	207,656	22,715	.....
1910...	24	2,351	307,320	27,376	708.0	1,866	.....	167,712	350	252,565	17,594	.....
1911...	24	1,923	324,000	27,735	741.2	2,208	.....	195,276	560	289,383	24,867	.....
1912...	51	1,674	278,927	26,970	1435.0	4,050	.....	233,600	400	324,352	23,292	.....
1913...	.....	.....	.....	27,940	740.0	.....	.....	.....	.....	.....	.....	.....

(a) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Boletin.* (b) Includes asphaltum and bituminous schist.

SPAIN

The following tables record the mineral and metal production of Spain, as reported by official authorities. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF SPAIN. (*a*)
(In metric tons.)

Year.	Aluminous Earths.	Antimony Ore.	Arsenic.	Asphaltum.	Asphalt. Rock.	Barytes.	Cement, Hydraulic.	Coal.	
								Anthracite.	Bituminous.
1899...	685	50	101	2,646	2,542	887	165,645	34,842	2,565,437
1900...	420	30	150	2,331	4,193	833	185,811	68,427	2,514,545
1901...	305	10	120	4,182	3,956	1,067	189,909	85,266	2,566,591
1902...	337	67	*Nil.*	6,034	6,301	642	201,856	109,298	2,614,010
1903...	381	42	1,088	4,675	6,277	507	245,294	108,959	2,587,652
1904...	925	245	400	3,463	3,761	453	286,737	163,275	2,903,771
1905...	221	77	1,140	5,805	5,725	290	296,605	159,517	2,912,466
1906...	386	180	1,114	6,229	7,794	330	299,294	113,747	3,095,043
1907...	1,209	205	1,500	8,643	8,219	314	329,926	164,498	3,531,337
1908...	60	124	2,004	9,231	12,373	334	343,001	188,463	3,696,653
1909...	35	(*b*)	506	6,582	5,284	422	472,909	198,302	3,662,573
1910(*f*)	400	15	444	8,473	7,795	476	484,161	211,958	3,600,056
1911...	461	100	331	3,495	6,500	635	486,085	209,227	3,451,384
1912(*h*)...	.....	500	.....	5,387	.....	1,096	.....	226,663	3,625,666

Year.	Coal (*Continued*).		Coke.	Copper Ore.		Copper.			Fluorspar.
	Lignitic.	Briquets.		Argentiferous.	Pyritic.	Fine.	Matte.	Precipitate.	
1899...	70,901	348,838	341,443	1,103	2,443,044	4	15,755	41,927	310
1900...	91,133	341,156	381,000	2,006	2,714,714	5	18,159	29,652	4
1901...	95,867	338,684	455,586	(*b*)	2,672,365	79	15,634	28,433	(*b*)
1902...	84,242	331,957	404,503	878	2,617,776	(*b*)	.....	36,045	93
1903...	104,232	339,120	433,780	3,056	2,796,733	(*b*)	.....	27,448	4,000
1904...	100,773	307,630	432,726	(*b*)	2,624,512	(*b*)	8,117	29,494	(*b*)
1905...	168,994	290,830	448,073	(*b*)	2,621,054	(*b*)	8,243	17,988	(*b*)
1906...	189,048	311,328	435,808	(*b*)	2,888,778	(*b*)	9,068	19,200	70
1907...	191,001	355,718	476,360	(*b*)	3,182,645	(*b*)	9,886	20,887	270
1908...	223,160	296,216	477,059	(*b*)	2,985,779	(*b*)	205	19,599	253
1909...	265,019	(*b*)	500,909	(*b*)	2,955,254	(*b*)	2,077	16,641	246
1910(*f*)	245,518	474,891	521,078	(*b*)	3,231,418	85	2,684	14,056	180
1911...	252,051	478,143	516,342	(*b*)	3,284,134	(*g*)76	1,910	12,353	499
1912...	283,480	465,106	489,558	.....	3,366,165	.....	1,861	.....	265

Year.	Iron Ore.		Iron and Steel.			Kaolin (China Clay).	Lead (Argentiferous).	
	Argentiferous.	Non-Argentiferous.	Pig.	Wrought Iron.	Iron and Steel Worked.		Ore.	Metal.
1899...	17,139	9,397,738	113,071	40,332	112,982	2,790	184,906	70,874
1900...	26,348	8,675,749	91,126	54,307	144,355	3,794	182,016	74,341
1901...	27,726	7,906,517	135,600	47,085	121,023	2,220	207,168	73,895
1902...	24,361	7,904,555	330,747	.....	163,564	3,412	227,645	74,370
1903...	90,996	8,304,153	380,284	.....	199,642	2,578	179,858	56,687
1904...	122,109	7,964,748	283,819	50,858	186,705	1,700	177,104	57,956
1905...	152,027	9,007,245	305,462	11,366	223,545	720	160,381	56,361
1906...	126,445	9,448,533	315,309	6,035	274,280	610	158,425	53,856
1907...	(*b*)	9,896,178	355,240	14,767	310,125	640	165,289	51,430
1908...	(*b*)	9,271,592	403,554	21,807	262,843	1,370	165,382	53,741
1909...	3,813	8,786,021	428,622	24,187	218,410	570	161,496	43,552
1910(*f*)	46,161	8,666,795	373,322	59,133	201,796	1,496	150,592	38,548
1911...	.....	8,773,691	408,667	11,166	264,930	4,469	156,569	40,379
1912...	1,588	9,133,007	366,136	.....	.....	4,920	93,850	49,212

Year.	Lead (Non-Argentiferous).		Manganese Ore.	Mineral Paints (Ocher).	Phosphate Rock.	Pyrites (Iron).	Pyrites (Arsenical).	Quicksilver.	
	Ore.	Metal.						Ore.	Metal.
1899 ...	123,753	91,730	104,974	100	3,510	107,386	(b)	32,144	1,361
1900 ...	131,437	98,189	112,897	58	4,170	34,638	515	30,216	1,095
1901 ...	174,376	95,399	60,325	164	4,220	33,953	1,328	23,367	754
1902 ...	100,403	103,190	46,069	(b)	1,150	145,173	5,648	26,037	1,425
1903 ...	108,660	118,422	26,194	(b)	1,124	155,739	7,996	30,370	968
1904 ...	93,230	127,906	18,732	(b)	3,305	161,841	3,510	27,185	1,130
1905 ...	105,113	129,332	26,020	(b)	1,370	179,079	4,790	26,485	853
1906 ...	105,095	131,614	62,822	164	1,300	189,243	2,434	28,965	1,568
1907 ...	103,632	135,066	41,504	114	3,547	225,830	3,423	28,789	1,212
1908 ...	126,667	134,321	16,745	400	4,483	263,451	5,533	42,210	1,068
1909(f).	137,050	136,441	7,827	418	1,387	258,931	3,235	37,398	1,393
1910 ...	216,738	151,975	8,607	759	2,840	294,184	1,461	22,714	1,114
1911 ...	165,843	149,540	5,607	622	3,520	344,879	1,056	19,940	1,494
1912...	190,162	183,400	17,400	.....	3,292	421,070	.....	21,889	1,256

Year.	Salt.	Silver.		Soapstone.	Sulphur.		Tin Ore. Dressed.	Topaz Kg.	Tungsten Ore.	Zinc.		
		Ore.	Metal. Kg.		Crude Rock.	Refined.				Ore.	Spelter.	Sheets.
1899..	598,108	764	88,409	4,814	58,922	1,100	57	44	151	119,710	4,100	2,084
1900..	450,041	742	140,457	8,109	64,364	750	47	95	1,958	86,158	2,855	2,756
1901..	345,063	391	94,977	4,880	49,856	610	115	310	6	119,708	2,573	2,781
1902..	426,434	175	96,975	542	15,442	450	12,762	Nil.	11	127,618	5,569	(b)
1903..	427,394	231	112,978	3,725	38,573	1,608	330	90	Nil.	154,126	5,134	(b)
1904..	543,658	303	117,418	5,165	40,389	605	229	....	60	156,329	5,887	2,913
1905..	493,451	540	123,607	4,364	38,153	610	209	....	375	160,561	6,184	2,936
1906..	541,978	470	126,424	3,609	28,965	700	86	171	430	170,384	6,209	2,639
1907..	605,895	702	127,435	13,875	27,054	3,612	315	266	386	191,853	6,144	2,485
1908..	822,677	441	129,881	4,730	13,872	2,988	838	(b)	226	156,233	6,357	2,693
1909(f	800,703	388	143,403	5,533	21,750	3,429	(e) 1,555	(b)	129	163,522	9,625	(b)
1910..	678,057	217	129,157	4,665	30,113	3,834	35	149	153	156,113	8,557	2,722
1911..	654,767	858	110,082	5,647	40,662	6,580	34	.....	96	162,140	2,904	3,429
1912..	23,292	688	143,400	.....	42,344	4,592	5,079	.....	169	175,311	8,451	.....

(a) Figures are from *Estadistica Minera de España*, except for 1896 and 1898, which were from the official *Reports of the Junta Superior Facultativa de Minas* Madrid. (b) Not reported. (c) Represents non-argentiferous copper ore. (e) Undressed tin ore. (f) *Revista Minera*. June 24, 1911. (g) Blister copper 18,295 tons; copper sulphate 15,893 tons. (h). *Revista Minera*. Apr. 24, 1914.

SWEDEN

The official statistics of mineral production, imports and exports, are summarized in the following tables. Figures given in bold face are either provisional figures or estimates.

MINERAL PRODUCTION OF SWEDEN. (a)
(In metric tons.)

Year.	Alum.	Coal.	Copper.			Feldspar.	Graphite.	Gold. *Kg.*
			Ore.	Ingot.	Sulphate.			
1901.....	121	271,509	23,660	137	1,224	13,502	56	62.7
1902.....	132	304,733	30,095	178	1,257	17,960	63	94.3
1903.....	140	320,390	36,637	776	1,171	19,392	25	50.6
1904.....	125	320,984	36,834	533	1,248	18,021	55	60.9
1905.....	139	322,384	39,255	1,385	1,029	19,224	40	55.0
1906.....	167	296,980	19,655	1,209	562	21,014	37	20.3
1907.....	131	305,338	21,957	1,577	782	20,244	33	28.1
1908.....	138	305,206	21,371	2,808	731	17,494	66	20.3
1909.....	132	246,808	9,562	2,375	628	15,772	26	14.1
1910.....	182	302,786	3,638	3,111	20	21,591	49	2.
1911.....	159	311,809	1,623	3,221	320	36,235	65	11.
1912.....	145	360,291	3,059	3,957	870	34,305	79	30.5
1913.....	159	363,965	.....	6,891	.....	.....	88	26.7

Year	Iron and Steel.					Steel.		
	Ore.	Pig.	Blooms.	Bars, Rods, Sheets, etc.	Iron Sulphate.	Bessemer.	Basic.	Crucible
1901....	2,793,566	528,375	164,850	269,507	140	77,231	190,877	1,088
1902....	2,896,208	538,113	186,076	(b)	127	84,014	201,311	1,091
1903....	3,677,520	506,825	192,342	325,200	62	84,229	232,878	1,105
1904....	4,083,945	528,525	189,246	324,676	148	78,577	252,832	1,162
1905....	4,364,833	539,437	182,640	356,898	144	78,204	288,675	1,319
1906....	4,501,656	604,789	178,298	381,118	170	84,633	311,435	1,457
1907....	4,478,917	615,778	174,405	403,994	159	77,036	341,893	1,287
1908....	4,712,494	567,821	152,256	363,408	277	81,054	355,394	1,169
1909....	3,885,046	444,764	120,669	292,478	182	63,351	248,757	927
1910....	5,549,987	603,929	151,713	408,191	236	97,503	372,451	2,215
1911....	6,150,718	634,392	146,722	408,159	156	93,853	372 705	4,309
1912....	6,699,226	699,816	.....	.....	.....	107,254	307,637	.....
1913....	.....	735,000	.....	.....	.....	115,700	467,100	.....

Year.	Lead.	Manganese Ore.	Pyrites.	Silver-lead Ore.	Silver. *Kg.*	Sulphur.	Zinc Ore.
1901.....	988	2,271	*Nil.*	11,366	1,557	(b)	61,044
1902.....	843	2,850	*Nil.*	9,378	1,365	74	48,630
1903.....	678	2,244	7,793	9,792	1,005	(b)	48,783
1904.....	589	2,297	15,957	8,187	651	35	62,927
1905.....	576	1,992	20,762	8,397	606	0	57,634
1906.....	753	2,680	21,827	1,938	938	0	56,885
1907.....	813	4,334	27,113	1,987	929	0	52,552
1908.....	277	4,616	29,569	2,058	630	0	50,884
1909.....	166	5,212	16,104	1,721	512	0	40,077
1910.....	355	5,752	25,445	2,700	30	0	43,760
1911.....	1,134	5,377	30,096	2,999	1,289	0	49,453
1912.....	1,073	5,101	31,835	2.877	962	.....	51,242
1913.....	1,235	4,001	34,319	3,222	1,037	.....	50,036

(a) From *Bidrag till Sveriges Officiela Statistik Bergshandteringen*, (b) Not reported.

MINERAL IMPORTS OF SWEDEN. (*a*)
(In metric tons or dollars; 1 krone = 27 cents).

Year.	Asbestos. (*c*)	Asphalt.	Barytes.	Borax.	Boric Acid.	Bromine and Bromides. *Kg.*	Cement.	Chalk, White, Unground. *Hectoliters.*	Coal.
1900....	763	5,676	411	194	66	6,084	1,941	12,059	3,033,885
1901....	178	4,524	295	253	68	6,602	2,868	13,569	2,793,309
1902....	213	5,779	.....	242	71	7,278	9,822	11,583	2,911,286
1903....	217	5,957	.....	240	71	7,419	11,145	41,868	3,192,990
1904....	356	6,243	.....	299	77	10,128	10,526	10,115	3,367,826
1905....	140	4,760	264	294	82	18,788	10,999	13,305	3,297,485
1906....	287	7,134	559	321	79	9,908	13,136	10,777	3,718,884
1907....	672	8,213	610	490	85	6,784	17,801	(*g*) 860	4,146,785
1908....	505	6,368	514	347	71	11,499	6,158	(*g*) 419	4,427,507
1909....	383	7,922	529	365	76	10,280	12,944	(*g*) 512	4,084,055
1910....	671	7,406	625	379	92	10,913	15,438	(*g*) 473	4,180,250
1911....	1,011	6,803	607	381	76	16,819	24,830	(*g*) 605	3,964,870
1912....	635	7,645	644	434	199	9,319	17,438	(*g*) 422	4,293,719
1913....	1,094	6,809	610	.....	.....	.....	12,120	(*g*)2,337	4,878,854

Year.	Copper, also Alloys of Copper.	Emery.	Graphite.	Gypsum	Iron (crude).	Lead.	Litharge.	Phosphorus. *Kg.*	Platinum. *Kg.*
1900....	4,745	136	213	6,794	82,957	2,067	148	67,557	59
1901....	5,153	169	180	6,589	66,131	1,991	165	70,672	172
1902....	6,890	147	(*b*)	6,754	43,828	2,509	172	68,441	130
1903....	6,109	132	(*b*)	8,795	49,411	2,644	237	112,659	116
1904....	7,367	221	(*b*)	8,868	90,102	2,849	213	47,421	84
1905....	6,481	271	(*b*)	11,270	87,843	2,823	205	69,526	105
1906....	8,899	284	(*b*)	13,496	108,193	3,457	255	79,048	133
1907....	(*c*) 14,213	336	375	15,037	115,186	3,384	210	77,936	109
1908....	(*c*) 12,392	308	540	11,644	109,841	3,964	248	107,301	117
1909....	(*c*) 11,000	428	443	14,212	99,519	3,222	217	88,241	72
1910....	(*c*) 13,297	438	398	15,816	117,180	3,453	267	99,145	77
1911....	14,014	459	398	14,505	114,859	2,901	270	77,837	103
1912....	7,470	490	513	10,467	140,145	1,204	316	88,411	12
1913....	.....	667	576	13,284	102,744	.....	.....	.....	.....

Year.	Potassium.				Quicksilver. *Kg.*	Salt.		Silver.	
	Chloride.	Cyanide *Kg.*	Hydrate.	Carbonate.		Crude.	Refined.	Bullion and Mfres. *Kg.*	Specie.
1900.....	364	2,221	1,915	1,257	3,629	70,302	3,098	11,559	$ 62,315
1901.....	260	2,658	1,435	1,266	5,958	79,038	3,072	7,476	78,416
1902.....	222	2,950	1,720	1,238	4,866	82,439	3,037	4,853	74,826
1903.....	245	3,294	2,034	1,150	5,043	88,139	3,419	11,259	90,366
1904.....	214	3,237	2,234	1,184	5,768	84,237	4,615	19,034	86,891
1905.....	1,296	3,437	2,251	1,133	4,609	87,677	3,889	11,067	82,620
1906.....	1,986	4,106	2,486	1,082	5,535	88,341	3,700	15,253	93,990
1907.....	1,840	4,150	2,484	1,269	8,930	(*h*) 835,190	18,821	26,334	52,074
1908.....	2,190	3,563	2,835	1,209	7,299	(*h*) 903,633	24,394	20,149	93,669
1909.....	1,809	3,808	2,627	1,312	6,077	(*h*) 766,195	24,143	17,315	154,265
1910.....	2,335	4,272	2,767	1,346	7,079	(*h*) 766,512	22,425	21,162	75,604
1911.....	1,288	4,993	3,737	1,268	4,164	(*h*) 736,935	26,026	15,175	134,407
1912.....	228	7,545	(*i*)3,262	1,380	5,110	1,050	22,009	21,220	164,781
1913.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		
	Carbonate.	Hydrate.	Nitrate. (*d*)	Sulphate (*e*).			Salts-*Kg.*	Block.	Zinc.
1901....	13,669	800	17,614	15,494	20,715	1,950	2,334	541	2,900
1902....	.....	1,623	15,553	18,924	23,002	1,887	1,652	644	3,255
1903....	.....	1,426	20,616	16,120	24,577	2,620	1,467	655	3,312
1904....	11,898	2,112	19,776	17,596	18,248	2,001	1,460	719	3,705
1905....	13,592	1,489	23,183	17,115	18,631	3,424	1,722	597	3,780
1906....	14,974	1,478	27,174	19,948	22,745	2,535	1,102	819	4,484
1907....	14,970	1,628	26,181	21,486	25,456	2,628	6,117	891	5,407
1908....	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,626
1909....	13,490	1,119	28,849	20,226	26,836	1,955	1,357	794	5,294
1910....	15,594	1,260	32,315	22,429	38,530	2,707	1,161	764	5,843
1911....	15,777	2,501	31,324	27,482	34,622	861	915	866	5,951
1912....	18,255	.....	35,107	26,540	38,471	593	73,045	1,032	4,617
1913....	.....	.....	.....	.....	.....	.....	.....	.....	.....

MINERAL EXPORTS OF SWEDEN. (*a*)
(In metric tons or dollars; 1krone=27 cents.)

Year.	Alum.	Ammonium Sulphate	Antimony, Crude-*Kg.*	Asbestos. *Kg.*	Cement.	Coal. (Anthracite.)	Copper.		Graphite.
							Ore.	Copper and Alloys.	
1899 ...	26	2	2,600	2,812	31,101	762	315	1,230	17
1900 ...	24	2	4,600	2,436	42,564	1,108	448	2,012	18
1901 ...	56	156	1,800	2,179	17,794	716	602	1,243	19
1902 ...	20	174	4,090	1,864	19,499	866	845	1,516	5
1903 ...	22	*Nil.*	3,473	15,357	21,319	509	1,555	1,858	9
1904 ...	9	219	3,810	16,339	27,509	605	749	1,396	(b)
1905 ...	12	445	3,147	2,386	38,504	425	2,137	2,654	(b)
1906 ...	11	30	4,584	1,510	45,960	1,352	1,841	2,662	(b)
1907 ...	7	*Nil.*	4,485	2,167	18,053	2,925	882	2,762	8
1908 ...	9	202	4,188	1,612	34,164	1,293	1,114	3,299	18
1909 ...	5	331	6,536	1,093	33,197	771	723	3,264	7
1910 ...	11	704	4,555	1,242	73,351	776	878	2,590	7
1911 ...	2	253	7,320	760	108,653	1,045	1,114	2,500	12
1912 ...	15	42	9,151	564	127,142	684	1,577	4,273	9
1913 ...	6	254	6,803	1,066	137,074	419	1,709	3,495	48

Year.	Gypsum and Mfres.	Iron and Steel.		Lead and Mfres.	Peat.	Phosphorus. *Kg.*	Potassium Chloride.
		Ore.	Unwrought.				
1899.....	8	1,628,011	320,742	818	1,979	1,890	335
1900.....	10	1,619,902	304,175	1,209	3,843	879	931
1901.....	55	1,761,257	268,143	1,028	3,064	1,254	706
1902.....	117	1,729,000	(*f*) 73,403	546	3,620	1,290	1,114
1903.....	119	2,828,000	(*f*) 70,788	333	3,217	300	790
1904.....	162	3,065,522	(*f*) 88,124	275	4,212	1,994	1,266
1905.....	156	3,316,626	(*f*)120,987	512	5,157	34,388	1,499
1906.....	6	3,661,218	(*f*)112,719	531	6,531	700	(b)
1907.....	16	3,521,717	201,643	519	6,524	(b)	(b)
1908.....	37	3,654,268	159,095	496	5,559	400	1,363
1909.....	21	3,204,522	161,757	319	9,999	1,305	1,400
1910.....	41	4,434,805	213,861	557	9,754	265	1,383
1911.....	13	5,086,898	226,044	1,181	10,371	595	1,564
1912.....	2	5,520,653	213,619	1,003	7,276	600	1,653
1913.....	1	6,413,644	216,013	745	7,135	900	1,423

Year.	Salt. Refined *Kg.*	Silver. Bullion. *Kg.*	Soda. (Carbonate.)	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfres-*Kg.*	Ore.	Crude and Mfrs.
1899....	110	367	227	68	8.8	1,033	45,635	157
1900....	407	296	238	20	21.5	1,521	40,879	157
1901....	1,556	179	237	12	20.4	8,110	41,248	101
1902....	1,945	110	621	147	25.5	1,603	43,813	63
1903....	*Nil.*	484	10	217	43.3	3,893	45,389	351
1904....	1,883	115	45	4	45.6	3,479	44,259	332
1905....	*Nil.*	10	403	4	33.9	654	51,765	295
1906....	8,652	77	463	12	51.0	353	45,380	410
1907....	4,452	160	39	1	67.9	2,518	41,236	529
1908....	14,300	136	114	7	53.9	274	38,543	908
1909....	6,422	437	27	5	42.5	276	38,865	1,200
1910....	1,326	814	31	6	51.1	356	40,405	1,278
1911....	3,450	1,090	40	7	66.0	152	41,854	2,158
1912....	1,668	2,021	3	75	110.0	698	41,985	3,136
1913....	6,916	4,300	2	239	87.0	2,640	46,696	6,533

(*a*) From *Bidrag till Sveriges Officiella Statistik* and *Sveriges Utförsel och Införsel.* (*b*) Not reported. (*c*) Includes crude and manufactures. (*d*) Includes a small quantity of potassium nitrate. (*e*) Includes sodium bisulphate. (*f*) Includes only crude or ballast iron. (*g*) Metric tons. (*h*) Hectoliters. (*i*) Includes sodium hydroxide.

Year	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		
	Carbonate.	Hydrate.	Nitrate. (*d*)	Sulphate (*e*).			Salts-*Kg.*	Block.	Zinc.
1901....	13,669	800	17,614	15,494	20,715	1,950	2,334	541	2,906
1902....	.....	1,623	15,553	18,924	23,002	1,887	1,652	644	3,203
1903....	.....	1,426	20,616	16,120	24,577	2,620	1,467	655	3,311
1904....	11,898	2,112	19,776	17,596	18,248	2,001	1,460	719	3,776
1905....	13,592	1,489	23,183	17,115	18,631	3,424	1,722	597	3,750
1906....	14,974	1,478	27,174	19,948	22,745	2,535	1,102	819	4,684
1907....	14,970	1,628	26,181	21,486	25,456	2,628	6,117	891	5,437
1908....	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,828
1909....	13,490	1,119	28,849	20,226	26,836	1,955	1,357	794	5,294
1910....	15,594	1,260	32,315	22,429	38,530	2,707	1,161	764	5,543
1911....	15,777	2,501	31,324	27,482	34,622	861	915	866	5,951
1912....	18,255	.....	35,107	26,540	38,471	593	73,045	1,032	4,917
1913....	.....	.....	.....	.....	.....	.....	.....	.....	.....

MINERAL EXPORTS OF SWEDEN. (*a*)
(In metric tons or dollars; 1krone = 27 cents.)

Year.	Alum.	Ammonium Sulphate	Antimony. Crude-*Kg.*	Asbestos. *Kg.*	Cement.	Coal. (Anthracite.)	Copper.		Graphite
							Ore.	Copper and Alloys.	
1899 ...	26	2	2,600	2,812	31,101	762	315	1,230	17
1900 ...	24	2	4,600	2,436	42,564	1,108	448	2,012	18
1901 ...	56	156	1,800	2,179	17,794	716	602	1,243	19
1902 ...	20	174	4,090	1,864	19,499	866	845	1,516	5
1903 ...	22	*Nil.*	3,473	15,357	21,319	509	1,555	1,858	9
1904 ...	9	219	3,810	16,339	27,509	605	749	1,396	(*b*)
1905 ...	12	445	3,147	2,386	38,504	425	2,137	2,654	(*b*)
1906 ...	11	30	4,584	1,510	45,960	1,352	1,841	2,662	(*b*)
1907 ...	7	*Nil.*	4,485	2,167	18,053	2,925	882	2,762	8
1908 ...	9	202	4,188	1,612	34,164	1,293	1,114	3,299	18
1909 ...	5	331	6,536	1,093	33,197	771	723	3,264	7
1910 ...	11	704	4,555	1,242	73,351	776	878	2,580	7
1911 ...	2	253	7,320	760	108,653	1,045	1,114	2,500	12
1912 ...	15	42	9,151	564	127,142	684	1,577	4,273	9
1913 ...	6	254	6,803	1,066	137,074	419	1,709	3,495	48

Year.	Gypsum and Mfres.	Iron and Steel.		Lead and Mfres.	Peat.	Phosphorus. *Kg.*	Potassium Chlorate
		Ore.	Unwrought.				
1899.....	8	1,628,011	320,742	818	1,979	1,890	33
1900.....	10	1,619,902	304,175	1,209	3,843	879	93
1901.....	55	1,761,257	268,143	1,028	3,064	1,254	71
1902.....	117	1,729,000	(*f*) 73,403	546	3,620	1,290	1,11
1903.....	119	2,828,000	(*f*) 70,788	333	3,217	300	71
1904.....	162	3,065,522	(*f*) 88,124	275	4,212	1,994	1,20
1905.....	156	3,316,626	(*f*)120,987	512	5,157	34,388	1,46
1906.....	6	3,661,218	(*f*)112,719	531	6,531	700	(*b*)
1907.....	16	3,521,717	201,643	519	6,524	(*b*)	(*b*)
1908.....	37	3,654,268	159,095	496	5,559	400	1,30
1909.....	21	3,204,522	161,757	319	9,999	1,305	1,40
1910.....	41	4,434,805	213,861	557	9,754	265	1,38
1911.....	13	5,086,898	226,044	1,181	10,371	595	1,50
1912.....	2	5,520,653	213,619	1,003	7,276	600	1,62
1913.....	1	6,413,644	216,013	745	7,135	900	1,42

Year.	Salt. Refined *Kg.*	Silver. Bullion. *Kg.*	Soda. (Carbonate.)	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfres-*Kg.*	Ore.	Crude and Mfrs.
1899....	110	367	227	68	8.8	1,033	45,635	157
1900....	407	296	238	20	21.5	1,521	40,879	157
1901....	1,556	179	237	12	20.4	8,110	41,248	101
1902....	1,945	110	621	147	25.5	1,603	43,813	63
1903....	*Nil.*	484	10	217	43.3	3,893	45,389	351
1904....	1,883	115	45	4	45.6	3,479	44,259	332
1905....	*Nil.*	10	403	4	33.9	654	51,765	295
1906....	8,652	77	463	12	51.0	353	45,380	410
1907....	4,452	160	39	1	67.9	2,518	41,236	529
1908....	14,300	136	114	7	53.9	274	38,543	908
1909....	6,422	437	27	5	42.5	276	38,865	1,200
1910....	1,326	814	31	6	51.1	356	40,405	1,278
1911....	3,450	1,090	40	7	66.0	152	41,854	2,158
1912....	1,668	2,021	3	75	110.0	698	41,985	3,136
1913....	6,916	4,300	2	239	87.0	2,640	46,696	6,533

(*a*) From *Bidrag till Sveriges Officiella Statistik* and *Sveriges Utförsel och Införsel.* (*b*) Not reported. (*c*) Includes crude and manufactures. (*d*) Includes a small quantity of potassium nitrate. (*e*) Includes sodium bisulphate. (*f*) Includes only crude or ballast iron. (*g*) Metric tons. (*h*) Hectoliters. (*i*) Includes sodium hydroxide.

UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables. Figures given in bold face are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM. (a)

(In metric tons.)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals.	Bauxite.	Chalk.	Clay. (e)	Coal.
1901....	4,019	3,416	2,620	26,844	10,357	4,399,043	14,393,196	222,614,981
1902....	5,755	2,165	842	23,986	9,192	4,466,004	15,549,002	230,728,562
1903....	3,337	916	58	24,659	6,226	4,541,494	16,460,526	234,019,821
1904....	6,636	992	44	26,748	8,839	4,509,768	16,210,734	236,130,373
1905....	7,245	1,552	651	29,528	7,417	4,608,153	15,376,910	239,906,999
1906....	9,605	1,625	650	36,319	6,760	4,825,299	12,459,213	255,067,622
1907....	10,063	1,523	1,800	42,648	7,658	4,855,857	15,065,141	272,097,858
1908....	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909....	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890
1910....	6,781	2,187	958	45,384	4,208	4,705,766	(h)14,316,469	268,677,182
1911....	10,685	2,178	1,189	44,826	6,103	.....	14,057,090	276,255,764
1912....	.....	2,228	1,806	43,453	5,882	4,962,408	.....	264,749,661
1913....	.....	1,716	35	48,792	6,153	.....	.....	292,047,544

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (Ireland) (c)
	Ore and Precipitate.	Fine.		Ore.	Bullion. Kg.			
1901.....	6,903	541	4,232	16,641	194.5	1,990,926	204,045	2,649
1902.....	6,210	490	6,388	30,432	130.0	2,100,829	228,264	4,983
1903.....	6,977	545	12,102	29,057	171.0	2,281,689	223,426	4,156
1904.....	5,552	501	18,450	23,574	610.7	2,275,426	237,749	4,616
1905.....	7,267	727	40,079	16,237	169.0	2,277,486	259,596	3,256
1906.....	7,882	(b)	42,521	17,662	(b)	2,404,857	228,627	5,512
1907.....	6,867	677	50,257	13,186	59.4	2,438,798	239,285	6,391
1908.....	5,528	588	35,257	7,237	28.5	2,228,245	231,980	4,364
1909.....	3,777	442	43,165	5,627	37.6	2,199,583	242,832	2,719
1910.....	4,245	456	62,607	6,252	75.5	2,235,160	259,661	2,603
1911.....	3,314	398	56,117	2,796	13.2	2,311,694	281,125	2,743
1912.....	1,942	.....	29,154	173	(b)	.....	247,724	(b)
1913.....	2,108	.....	34,377	4	.....	.....	242,341	.....

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1901....	12,475,700	4,158,745	33,084	20,361	1,673	14,780	2,392,812	71
1902....	13,641,459	4,470,420	25,000	17,988	1,299	17,235	2,141,355	87
1903....	13,935,748	4,573,202	26,993	20,278	831	14,377	2,041,851	71
1904....	13,994,670	4,596,803	26,796	20,155	8,896	16,307	2,370,391	59
1905....	14,824,183	(f)9,746,221	28,091	20,977	14,582	16,468	2,536,784	Nil.
1906....	15,748,412	(f)9,999,211	30,710	22,693	23,126	14,437	2,586,851	Nil.
1907....	15,983,310	(f)9,850,953	33,053	24,853	16,356	14,927	2,732,968	33
1908....	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	9
1909....	15,220,408	(f)9,818,916	30,221	22,823	2,812	16,575	3,014,678	4
1910....	15,470,392	5,055,595	28,992	21,867	5,554	16,782	3,180,520	(b)
1911....	15,768,511	5,101,089	24,186	18,279	5,067	14,819	3,166,838	(b)
1912....	8,552,343	**8,889,000**	25,729	.....	4,237	.....	3,235,942	.....
1913....	9,746,178	**10,479,171**	24,656	.....	5,480	.....	3,333,048	.....

Year.	Pyrites.	Salt.	Silica (chert and flint).	Silver. *Kg.*	Stone.			
					Igneous Rock.	Limestone. (*d*)	Sandstone.	Slate.
1901.....	10,405	1,812,180	132,700	5,452	5,131,787	11,363,202	5,199,234	496,756
1902.....	9,315	1,893,881	100,938	4,560	5,554,696	12,368,196	5,571,121	525,665
1903.....	9,794	1,917,274	74,355	5,440	5,512,605	12,419,120	5,496,312	540,143
1904.....	10,452	1,921,899	66,300	4,967	6,084,642	12,235,825	5,391,265	572,181
1905.....	12,381	1,920,149	71,808	5,212	6,052,210	12,701,808	5,729,799	523,892
1906.....	11,318	1,996,593	69,300	(*b*)	6,264,402	12,962,725	5,345,328	500,546
1907.....	10,358	2,016,409	54,523	4,780	5,765,262	12,709,288	5,092,246	450,651
1908.....	9,600	1,873,555	64,813	4,207	6,211,860	11,977,007	5,105,481	420,979
1909.....	8,964	1,851,999	53,063	4,421	6,384,144	12,000,790	4,673,839	408,639
1910.....	10,393	2,083,543	75,089	4,251	6,714,774	12,713,565	4,456,679	423,006
1911.....	10,276	2,116,115	72,726	3,684	6,629,417	12,378,725	4,109,828	431,948
1912.....	10,691	.....	.....	.....	.....	.....	.....	.....
1913.....	11,611	.....	.....	.....	.....	.....	.....	.....

Year.	Strontium Sulphate.	Tin.		Tungsten Ore.	Uranium Ore.	Zinc.	
		Ore Dressed.	Block.			Ore.	Spelter.
1901.....	16,923	7,407	4,634	21	80	23,967	8,555
1902.....	32,799	7,681	4,462	9	53	25,462	9,275
1903.....	23,209	7,500	4,351	276	6	25,287	9,430
1904.....	18,460	6,849	4,198	164	*Nil.*	28,097	10,427
1905.....	14,523	7,316	4,540	174	105	24,025	9,023
1906.....	14,338	6,376	(*b*)	267	11	23,189	(*b*)
1907.....	10,917	7,192	4,478	327	72	20,402	7,222
1908.....	16,733	8,137	5,133	237	72	15,469	5,926
1909.....	14,267	8,422	5,282	382	6	10,061	5,828
1910.....	4,838	7,693	4,874	275	76	11,418	4,235
1911.....	5,963	7,870	4,950	270	68	17,935	6,196
1912.....	.....	6,926	.....	192	43	17,988	.....
1913.....	.....	7,054	.....	185	96	18,073	.....

(*a*) From *Mineral Statistics of the United Kingdom.* (*b*) Not reported. (*c*) Bog ore, which is mined in Ireland, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes China clay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*g*) Estimated. (*h*) Includes shale. (*i*) Partial figures available only.

MINERAL IMPORTS OF THE UNITED KINGDOM. (*a*)

(In metric tons or dollars; £1 = $5.)

Year.	Alkali.	Asphaltum.	Borax.	Coal, Coke and Pat. Fuel.	Copper.			Iron and Steel.		
					Ore.	Regulus and Precipitate.	Wrought, Unwrought and Old.	Iron Ore.	Pig Iron.	Scrap.
1902...	(*c*)26,292	65,896	13,390	3,331	90,007	74,684	92,349	6,542,793	226,708	39,584
1903...	(*c*)14,321	(*b*)	11,959	3,535	85,644	77,884	64,591	6,417,188	132,364	17,051
1904...	(*c*)14,325	(*b*)	16,012	2,812	80,771	67,739	90,717	6,198,368	132,494	19,326
1905...	(*c*)16,593	(*b*)	11,552	49,277	94,198	70,235	71,294	7,172,171	128,183	23,569
1906...	(*c*)14,070	(*b*)	16,955	49,269	97,789	76,073	75,487	7,634,839	90,674	36,559
1907...	(*c*)15,579	(*b*)	17,551	19,136	105,409	73,101	89,312	7,764,589	104,950	27,404
1908(*i*)	(*c*)13,732	(*b*)	(*n*)19,424	3,904	111,897	71,120	124,226	6,154,733	69,930	24,653
1909...	(*c*)10,857	(*b*)	(*n*)16,349	6,419	(*l*)90,579	(*l*)66,337	(*l*)133,758	(*l*)6,429,996	(*l*)111,300	(*l*)33,475
1910...	(*c*) 8,996	(*o*)14,415	16,277	36,615	99,755	70,081	89,279	7,133,483	173,568	70,176
1911...	(*c*) 9,463	(*o*)20,866	20,621	30,672	87,986	65,914	101,059	6,448,462	178,167	51,002
1912...	8,812	(*b*)	21,091	194,866	99,802	52,393	96,499	6,708,443	223,586	64,195
1913...	9,140	(*b*)	23,837	24,429	95,837	39,762	108,728	7,566,276	220,320	124,854

Year.	Iron and Steel. (*Continued*).								Lead.	
	Puddled and Wrought	Sheets and Plates.	Rails.	Strips and Wire Rods.	Nails, Screws, Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes, Beams, Pillars.	Mnfrs. Unenumerated. (*k*)	Ore.	Pig and Sheet.
1901..	102,811	(*f*)	55,809	(*f*)	(*f*)	185,810	124,648	$18,252,435	29,944	221,549
1902..	178,425	(*f*)	48,942	(*f*)	45,095	285,494	129,743	14,424,835	25,838	235,522
1903..	196,084	73,079	74,939	35,574	51,888	278,441	343,259	9,007,990	18,923	232,939
1904..	109,289	69,552	40,438	38,214	50,649	531,069	219,510	8,630,380	8,748	250,452
1905..	110,576	69,831	34,439	60,318	55,331	613,612	148,995	8,783,895	(*i*) 27,649	233,214
1906..	111,062	83,747	11,900	61,288	57,071	493,805	149,363	7,824,405	(*i*) 30,795	211,577
1907..	83,145	57,280	19,33	56,110	51,863	332,442	90,327	3,731,275	(*i*) 13,609	207,970
1908(*i*)	85,270	56,652	31,393	109,313	54,251	437,238	231,859	3,034,895	23,861	241,320
1909..	(*l*) 95,553	(*l*) 68,067	(*l*) 22,430	(*l*) 132,543	(*l*) 59,197	(*l*) 392,008	(*l*) 264,909	2,819,365	(*b*)	(*l*) 210,982
1910..	(*l*) 98,859	88,245	16,074	163,681	58,977	361,401	349,662	3,239,715	(*b*)	222,450
1911..	119,583	115,349	36,588	173,764	62,314	512,841	500,643	(*p*) 3,654,825	(*b*)	217,134
1912..	167,774	103,224	24,640	205,749	73,745	607,470	509,002	4270,000	(*b*)	208,671
1913..	204,218	172,301	38,701	225,690	66,086	568,512	597,591	10,098,040	(*b*)	207,559

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum, Wrought and Unwrought. *Kg.*	Potassium Nitrate.	Pyrites of Iron and Copper.
1901.....	195,736	(*b*)	7,117	42,643	960,650,967	360,568	4,917	12,115	664,041
1902.....	237,066	1,078	6,127	52,023	1,078,095,152	370,697	3,027	11,526	620,948
1903.....	235,574	(*b*)	(*b*)	49,163	1,299,570,625	398,997	(*b*)	9,425	747,714
1904.....	208,458	(*b*)	(*b*)	42,882	1,373,488,176	425,978	(*b*)	12,277	754,722
1905.....	289,827	(*b*)	(*b*)	41,247	1,364,301,583	427,762	(*b*)	8,260	709,925
1906.....	314,016	(*b*)	(*b*)	44,673	1,130,667,737	450,058	(*b*)	10,125	771,473
1907.....	513,750	(*b*)	(*b*)	46,542	1,382,595,355	512,601	(*b*)	10,719	781,486
1908 (*i*).....	349,694	(*b*)	(*b*)	(*n*) 46,504	(*n*) 1,300,726,576	537,628	(*b*)	(*n*) 11,913	771,091
1909.....	335,813	(*b*)	(*b*)	(*n*) 53,289	(*n*) 1,355,562,599	459,058	(*b*)	(*n*) 10,704	(*l*) 803,725
1910.....	489,948	(*b*)	(*b*)	(*n*) 54,073	(*n*) 1,308,396,240	462,905	(*b*)	11,558	825,284
1911.....	364,676	(*b*)	(*b*)	51,456	1,661,100,144	501,332	(*b*)	11,376	863,583
1912.....	393,798	(*b*)	(*b*)	74,836	1,879,486,588	528,620	(*b*)	11,034	921,717
1913.....	611,227	(*b*)	(*b*)	57,974	(*g*) 488,244,598	548,000	(*b*)	12,092	794,740

Year.	Quicksilver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin.		Zinc.		
					Ore.	Block, Ingot, Bars or Slabs.	Ore.	Spelter.	Mnfrs.
1901.....	1,202	$5,309,920	108,822	22,440	10,690	35,397	38,660	68,633	21,343
1902.....	1,129	5,383,515	116,791	23,863	12,255	37,713	45,312	89,688	21,717
1903.....	1,187	6,596,045	118,582	21,313	12,473	36,076	41,009	86,539	23,119
1904.....	1,130	8,271,480	122,454	17,629	15,734	39,932	54,438	90,088	22,788
1905.....	1,158	10,426,570	106,107	18,163	(*b*)	40,391	23,909	92,261	20,013
1906.....	1,320	10,532,020	110,222	22,704	21,003	44,306	(*i*) 22,824	95,203	19,664
1907.....	1,341	11,224,650	115,716	15,730	21,205	44,505	(*i*) 66,076	90,756	20,163
1908(*i*).....	1,483	10,743,400	(*n*) 148,056	(*n*) 19,580	25,414	48,496	61,661	91,548	38,717
1909.....	(*m*) 1,469	10,409,800	(*n*) 91,650	21,211	(*m*) 24,471	(*l*) 42,393	(*b*)	104,217	19,280
1910.....	1,517	9,311,665	128,528	20,496	26,490	47,028	(*b*)	123,061	18,490
1911.....	1,584	8,420,954	130,549	21,269	29,300	46,643	(*b*)	117,077	19,417
1912.....	1,607	7,523,692	125,664	22,109	29,112	43,850	(*b*)	139,461	20,873
1913.....	1,543	5,718,552	143,275	18,518	35,169	46,443	(*b*)	147,421	19,081

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Classified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and metal. (*e*) Includes puddled iron. (*f*) Not separately enumerated. (*g*) Returns not available. (*h*) Prior to 1900, many manufactures were not reported separately. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min. Journ.* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pipes, castings and forgings, amounting to 51,000 tons. (*q*) Gallons.

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS. (a)
(In metric tons or dollars; £1 = $5.)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products (c).
1901	46,912	318,216	42,547,114	820,594	1,098,459	13,804,222	5,756,265
1902	40,939	308,104	43,849,591	669,664	1,067,060	15,390,485	5,991,025
1903	49,415	406,388	45,669,258	728,957	970,449	17,068,646	7,290,825
1904	35,289	390,736	46,995,636	779,060	1,257,589	17,465,954	6,879,400
1905	42,526	463,863	48,236,334	786,498	1,126,190	17,674,484	6,742,455
1906	45,510	668,461	56,489,367	828,266	1,399,244	18,887,656	7,226,790
1907	48,856	777,741	64,621,743	997,170	1,504,661	18,917,660	7,726,685
1908	39,120	607,950	63,551,057	1,212,184	1,463,557	19,786,734	(n) 7,711,360
1909(k)...	(n) 46,321	607,825	64,089,132	(l) 1,180,218	(l) 1,479,142	20,029,427	(n) 7,276,050
1910	(n) 51,188	747,627	(l) 63,081,948	979,526	1,494,397	(l) 19,839,123	(n) 8,398,405
1911	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£1,880,253
1912.....	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,249,892
1913	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,665,652

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfres	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfres.	Wrought Iron, Shapes and Mfres
1901 ...	26,935	9,252	11,156	36,601	(d)	(e) 852,609	86,559	(b)	119,962
1902 ...	21,658	13,314	14,075	43,995	4,062	1,120,207	104,890	(b)	(b)
1903 ...	23,723	14,425	16,975	54,307	4,534	1,082,426	143,929	62,249	217,139
1904 ...	14,791	16,704	18,467	71,367	6,706	823,909	166,010	49,004	173,233
1905 ...	21,232	9,959	22,128	55,219	14,664	997,601	151,619	49,193	186,340
1906 ...	19,778	7,149	16,195	43,670	13,415	1,670,753	180,547	54,876	203,521
1907 ...	25,652	7,994	16,676	46,049	15,538	1,978,350	162,295	43,218	215,159
1908(k)	14,869	15,546	19,796	(m) 72,429	4,478	1,317,330	135,115	48,336	174,539
1909 ...	12,465	(m) 11,381	17,248	(m) 45,547	(l) 5,185	(l) 1,026,517	(l) 165,183	(l) 44,406	(l) 171,698
1910 ...	11,898	(m) 15,970	12,551	43,391	(l) 7,464	(l) 1,062,444	(l) 150,507	(l) 57,148	(q) 143,707
1911 ...	10,970	15,101	24,669	81,112	(l) 6,352	1,222,622	147,759	(l) 70,618	140,312
1912 ...	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
1913 ...	15,165	14,711	22,317	76,950	5,278	1,114,562	117,645	82,816	139,593

Year.	Iron. (*Continued.*)								
	Rails.	Wire and Mfrs., of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams and Pillars.	Total Iron and Steel, and Mfrs. of.
1901 ..	474,073	48,107	36,418	254,290	52,217	275,661	217,236	(b)	2,944,083
1902 ..	(b)	(b)	(b)	336,572	58,245	317,201	306,152	(b)	3,529,225
1903 ..	613,741	60,800	165,672	357,665	66,279	297,485	13,427	159,330	3,621,637
1904 ..	533,895	61,894	154,774	391,608	63,467	365,262	4,324	176,232	3,315,049
1905 ..	555,390	82,519	207,866	413,533	69,937	360,630	8,735	219,491	3,781,058
1906 ..	470,652	96,641	279,459	450,221	66,749	381,421	11,924	311,231	4,763,868
1907 ..	595,272	103.100	305,399	476,838	72,675	411,814	13,705	344,135	5,249,028
1908(k)	589,525	95,801	210,526	396,366	62,079	409,335	2,452	278,792	4,162,065
1909 ..	(l) 589,499	(l) 107,406	(l) 169,918	(l) 502,791	(l) 61,025	(l) 446,781	(l) 3,217	(l) 309,555	4,278,172
1910 ..	490,068	(l) 124,703	(l) 197,858	(l) 606,530	(l) 56,691	(l) 490,733	(l) 3,340	(q) 230,850	4,661,647
1911 ..	381,320	(l) 129,252	(l) 203,850	627,215	(l) 68,137	492,104	(f) 4,376	231,793	4,588,385
1912 ..	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
1913 ..	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456

Year.	Lead. Pig and Mfres.	Salt.	Sodium.				Tin. Block	Zinc.		
			Soda Ash.	Carbonate and Bicarbonate.	Hydrate.	Sulphate.		Ore.	Spelter.	Mfres.
1901 ..	38,166	627,078	58,412	22,161	50,624	26,057	5,584	13,981	7,512	1,256
1902 ..	33,537	624,752	59,894	24,654	61,658	35,672	6,210	16,717	6,756	1,345
1903 ..	36,152	594,300	58,605	23,574	59,725	45,630	6,349	15,659	8,192	(i)
1904 ..	35,600	632,605	61,327	25,252	61,985	40,324	5,953	14,606	7,930	(i)
1905 ..	42,265	588,389	67,678	28,425	68,675	33,681	7,741	(b)	7,451	(i)
1906 ..	45,612	629,658	86,232	26,970	72,218	44,448	8,631	(b)	7,962	(i)
1907 ..	44,068	592,989	91,120	29,539	70,432	45,898	8,808	11,511	6,666	(i)
1908(k)	50,221	532,101	(n) 83,713	(n) 20,805	(n) 73,769	(n) 22,974	9,486	3,833	8,537	(i)
1909 ..	(m) 46,399	523,690	(n) 97,480	(n) 23,378	(n) 80,439	(n) 35,587	11,373	(b)	(m) 8,684	(i)
1910 ..	47,588	571,845	110,188	23,295	84,291	58,960	12,576	(b)	9,247	(i)
1911 ..	44,733	614,572	125,945	26,353	82,356	59,382	11,736	(b)	9,736	(i)
1912 ..	47,782	557,291	144,073	29,403	79,527	50,759	12,152	(b)	10,881	.....
1913 ..	49,261	542,157	159,714	39,175	76,152	67,504	11,687	.....	11,313	.....

(a) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (b) Not reported. (c) Including naphtha, paraffin, paraffin oil and petroleum. (d) Previous reports not available. (e) Includes puddled iron. (f) Includes railroad material of all kinds. (g) Includes all soda compounds; not separate; enumerated previous to 1901. (h) Included under soda ash. (i) Included under spelter. (k) From *Mines and Quarries.* (l) From *Iron and Coal Trades Review.* (m) *Mining Journal.* (n) From *Oil Paint and Drug Reporter.* (q) Bars only.

UNITED STATES

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty free; the second shows the exports of materials produced in the United States: and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Statistics of the Department of Commerce and Labor, and special acknowledgment is due to A. H. Baldwin, chief of the bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given under the separate chapters.

IMPORTS. (a)

Year.	Aluminium. Crude. Lb.	Kg.	Value.	Value per Lb.	Ammonium Sulphate. Lb.	Metric Tons.	Value.	Value per Lb.
1904	515,416	234,293	$128,350	$0.249	39,859,690	18,077	$1,058,981	$0.027
1905	530,429	240,284	106,108	0.200	15,512,399	7,038	416,048	0.027
1906	770,713	349,195	154,292	0.200	31,797,291	14,423	894,663	0.028
1907	872,474	395,754	181,352	0.208	70,440,992	31,960	1,828,236	0.026
1908	465,317	210,785	80.268	0.173	76,475,104	34,698	1,982,830	0.026
1909	5,109,843	2,317,784	745,963	0.145	85,829,334	38,932	2,114,694	0.024
1910	(o)12,271,277	5,567,730	1,844,830	0.151	184,686,534	83,795	4,668,820	0.025
1911	4,173,308	1,893,000	598,272	0.143	189,265,797	85,850	5,066,470	0.027
1912	22,759,937	10,323,839	3,092,889	0.136	119,084,402	54,016	3,447,225	0.029
1913	23,185,775	10,510,324	3,905,997	0.169	131,550,031	59,687	3,957,307	0.030

Year.	Antimony. (r) Lb.	Metric Tons.	Value.	Value per Lb.	Antimony Ore. Lb.	Metric Tons.	Value.	Value per Lb.
1904....	4,056,299	1,840	$235,401	$0.058	2,487,602	1,129	$50,362	$0.020
1905....	5,737,891	2,603	431,774	0.075	1,976,694	897	52,868	0.027
1906....	7,900,194	3,583	1,417,816	0.179	2,247,131	1,019	128,347	0.057
1907....	8,662,683	3,928	1,423,276	0.164	2,780,186	1,261	180,903	0.065
1908....	8,114,651	3,954	572,979	0.071	3,280,922	1,488	106,930	0.033
1909....	9,652,568	4,335	619,179	0.064	3,386,708	1,575	94,249	0.027
1910....	9,899,514	4,487	572,031	0.058	*Nil.*	.....	.....	.....
1911....	10,957,844	4,970	573,564	0.052	*Nil.*	.....	.....	.....
1912...	17,645,870	8,004	936,920	0.053	*Nil.*	.....	.....	.....
1913....	15,333,632	6,957	878,773	0.057	76,160	34	1,739	0.023

Year.	Asbestos. Crude Value.	Mfd. Value.	Total Value.	Asphaltum. Long Tons.	Metric Tons.	Value.	Value per L. T.
1904 ...	$700,572	$51,290	$751,862	119,575	121,489	$510,524	$4.27
1905 ...	776,362	70,117	846,749	86,748	88,136	382,667	4.41
1906 ...	536,500	.....	.....	97,274	98,830	388,010	3.93
1907 ...	1,104,109	200,371	1,304,480	127,902	129,948	518,074	4.05
1908 ...	1,068,342	147,548	1,215,869	131,862	133,971	587,698	4.45
1909 ...	993,254	240,381	1,233,635	132,807	134,939	646,655	4.87
1910 ...	1,235,170	308,078	1,543,248	166,379	169,041	776,283	4.66
1911 ...	1,413,541	161,442	1,574,983	174,234	177,030	778,185	4.47
1912 ...	1,456,012	363,759	1,819,771	194,775	197,901	919,467	4.72
1913...	1,928,705	389,664	2,318,369	193,783	197,012	911,921	4.71

Year.	Arsenic.(b)				Barytes.				Bauxite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904....	6,391,566	2,900	$226,481	$0.036	6,689	6,796	$27,463	$4.11	15,475	15,723	$49,577	$3.20
1905....	6,444,083	2,924	219,198	0,034	7,879	8,005	36,796	4.67	11,726	11,914	46,517	3.96
1906....	7,639,507	3,464	336,609	0.044	4,293	4,362	37,296	8.69	17,809	18,094	63,221	3.55
1907....	9,922,870	4,500	553,440	0.056	28,350	28,804	174,225	6.15	25,065	25,466	93,208	3.72
1908....	9,592,881	4,558	417,137	0.056	n)12,196	12,390	58,822	4.83	21,679	22,033	87,823	4.05
1909....	7,183,644	3,259	272,493	0.038	n)13,091	13,301	54,707	4.19	18,989	18,689	83,956	4.49
1910....	8,257,474	3,745	251,716	0.031	n)16,960	17,226	48,457	2.86	14,038	14,258	65,743	4.68
1911....	5,404,263	2,451	159,626	0.030	20,860	21,195	58,726	2.82	43,222	43,916	164,301	3.80
1912....	6,758,946	3,066	246,815	0.037	26,665	27,093	79,315	2.97	26,214	26,635	95,431	3.64
1913....	6,688,216	3,034	285,537	0.043	36,875	37,490	99,564	2.97	21,456	21,814	85,746	3.99

Year.	Bismuth.				Chrome Ore.				Coal, Anthracite.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value	Value per L.T.
1904 .	147,712	67,002	$268,837	$1.82	24,227	24,615	$348,527	$14.38	72,526	73,686	$220,665	$3.04
1905 .	148,589	67,459	318,007	2.14	54,434	55,305	725,301	13.32	34,262	34,810	107,394	3.13
1906 .	254,733	115,000	318,452	1.25	43,441	44,136	557,594	12.84	32,357	32,875	105,190	3.25
1907 .	259,881	117,882	325,015	1.25	41,999	42,671	491,925	11.71	9,896	10,054	40,966	4.14
1908 .	164,793	73,002	257,397	1.56	27,876	28,320	345,960	12.40	16,483	16,747	73,777	4.47
1909 .	183,413	83,195	286,516	1.56	39,820	40,459	460,758	11.57	4,709	4,785	19,438	4.13
1910 .	198,174	89,916	332,674	1.67	38,579	39,196	415,768	10.77	8,196	8,327	42,234	5.14
1911 .	172,093	78,061	311,771	1.81	37,529	38,131	407,958	10.87	2,463	2,502	12,550	5.10
1912 .	182,839	82,935	316,440	1.73	53,929	54 795	499 818	9.27	1,670	1,697	8,329	4.99
1913 .	117,747	53,424	213,257	1.81	65,180	66,266	622,821	9.55	921	936	5,697	6.18

Year.	Coal, Bituminous.				Total Coal.		Coke.			
	Long Tons.	Metric Tons	Value.	Value per L.T.	Long Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1904....	1,556,149	1,581,047	$3,915,613	$2.52	1,628 675	$4,136,278	161,476	164,060	$648,520	$4.01
1905....	1,618,581	1,644,478	3,908,877	2.42	1,652,843	4,016,271	181,376	184,278	796,544	4.39
1906....	1,712,150	1,739,544	4,129,555	2.41	1,744,507	4,234,745	114,703	116,538	558,419	4.87
1907....	2,116,122	2,149,980	5,398,167	2.55	2,126,018	5,439,133	132,536	134,656	594,137	4.48
1908....	1,487,816	1,511,621	4,059,786	2.73	1,504,299	4,133,563	129,591	131,624	603,964	4.65
1909....	1,257,629	1,277,814	3,597,991	2.56	1,262,338	3,617,429	170,671	173,410	735,253	4.31
1910....	1,991,943	2,023,914	5,381,062	2.69	2,000,270	5,423,296	156,417	158,920	625,619	4.00
1911....	1,238,808	1,258,691	3,611,518	2.92	1,241,271	3,624,068	69,515	70,631	254,938	3.67
1912....	1,608,350	1,635,156	4,509,636	2.80	1,610,020	4,517,965	110,347	112,118	488,691	4.43
1913....	1,413,857	1,437,421	3,846,811	2.72	1,414,778	3,852,508	93,507	95,065	442,687	4.73

Year.	Chloride of Lime.				Cement.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Barrels. (c)	Metric Tons.	Value.	Value. per Bbl.
1904.....	87,909,168	39,876	$707,174	$0.008	1,046,404	189,910	$1,382,913	$ 1.32
1905.....	104,919,462	47,604	843,285	0.008	846,577	153,644	1,102,041	1.30
1906.....	105,221,371	47,718	863,490	0.008	2,205,712	400,115	2,950,268	1.33
1907.....	112,090,783	50,833	939,248	0.008	2,006,228	363,929	2,637,424	1.31
1908.....	74,602,059	33,848	621,713	0.008	839,246	152,313	1.189,560	1.42
1909.....	91,390,004	41,454	743,636	0.008	431,785	78,342	642,397	1.49
1910.....	101,029,345	45,839	797,260	0.008	292,314	53,053	396,428	1.36
1911.....	82,895,472	37,601	667,804	0.008	163,802	29,720	254,258	1.55
1912.....	74,235,256	33,673	597,002	0.008	65,064	11,805	93,583	1.44
1913.....	61,605,077	27,951	510,120	0.0084	77,333	14,035	134,187	1.74

Year.	Cobalt Oxide.				Copper, Ore and Matte.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904.....	42,352	19,211	$86,925	$2.05	268,234	272,527	$4,308,410	$16.06
1905.....	70,048	31,802	139,377	1.99	296,251	300,991	5,765,238	19.46
1906.....	41,084	18,652	83,167	2.02	208,702	212,041	6,796,696	32.56
1907.....	42,794	19,421	73,028	1.71	291,957	297,096	9,048,270	31.32
1908.....	1,550	701	3,095	2.00	288,022	292,630	6,978,513	24.20
1909.....	9,818	4,453	11,065	1.132	393,530	399,846	9,113,254	23.16
1910.....	6,124	2,778	4,806	0.785	453,747	461,007	9,182,161	20.23
1911.....	22,934	10,403	11,047	0.482	292,931	297,633	6,935,794	23.68
1912.....	31,848	14,446	15,132	0.475	499,549	507,567	12,696,532	25.42
1913.....	.....	.....	.....	.....	511,163	519,682	13,573,327	26.55

Year.	Copper, Ingots, Old, etc.				Cryolite.			
	Lb.	Metric. Tons.	Value.	Value. per Lb.	Long Tons.	Metric Tons.	Value.	Value. per L. T.
1904.....	142,344,433	64,567	$18,374,959	$0.129	959	974	$13,708	$14.30
1905.....	160,619,385	72,876	22,103,741	0.137	1,600	1,623	22,482	14.05
1906.....	176,558,390	80,069	30,416,578	0.172	1,505	1,529	29,683	19.72
1907.....	192,901,267	87,523	38,658,754	0.200	1,438	1,461	28,920	20.10
1908.....	162,224,144	73,604	22,851,134	0.141	1,124	1,142	16,445	14.63
1909.....	240,713,721	109,186	30,529,425	0.127	1,278	1,299	18,427	14.42
1910.....	259,210,796	117,609	31,620,689	0.122	36	.....	2,343	.....
1911.....	265,940,760	120,630	31,540,827	0.119	2,007	2,039	47,093	23.46
1912.....	305,369,592	138,515	44,259,727	0.145	2,126	2,160	48,293	22.72
1913.....	300,068,849	136,148	44,328,574	0.148	2,559	2,602	52,557	20.54

Year.	Emery Grains.				Emery Rock.			
	Lb.	Metric. Tons.	Value.	Value per Lb.	Long Tons.	Metric. Tons.	Value.	Value per L. T.
1904....	2,281,193	1,035	$109,772	$0.048	7,054	7,167	$131,493	$18.64
1905....	3,209,915	1,456	143,729	0.045	11,073	11,250	185,689	16.77
1906....	4,655,168	2,113	215,357	0.043	13,840	14,061	286,386	20.69
1907....	4,282,228	1,942	186,156	0.043	11,235	11,415	211,184	18.80
1908....	1,735,366	788	89,702	0.052	8,084	8,213	146,105	18.09
1909....	2,696,980	1,224	132,264	0.049	9,836	9,993	186,930	19.00
1910....	1,189,664	535	53,709	0.045	16,770	16,321	344,421	20.54
1911....	712,134	323	35,384	0.050	10,232	10,396	176,890	17.29
1912....	791,667	359	32,876	0.042	15,793	16,052	284,585	18.01
1913....	2,496,372	1,133	114,806	0.046	17,122	17,377	342,809	20.03

Year.	Fuller's Earth.		Gold.		Iron Ore.			
	Long Tons.	Value.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904...	9,126	$79,006	$75,646,128	$9,157,106	487,613	495,415	$1,101,384	$2.26
1905...	13,001	105,997	38,564,328	11,729,077	845,651	859,181	2,062,161	2.44
1906...	13,238	108,696	139,705,887	15,873,493	1,060,390	1,007,356	2,967,434	2.80
1907...	14,648	122,221	130,605,413	12,792,659	1,229,168	1,248,835	3,937,483	3.20
1908...	10,963	92,413	38,346,267	11,930,026	776,898	789,326	2,224,248	2.86
1909...	11,406	101,151	30,648,147	13,438,819	1,694,957	1,722,161	4,579,078	2.70
1910...	13,775	132,545	47,212,754	12,009,764	2,591,031	2,632,617	7,832,225	3.02
1911...	16,272	143,594	46,623,766	10,821,418	1,811,732	1,840,810	5,412,636	2.99
1912...	17,062	145,337	55,789,406	10,758,866	2,104,576	2,138,354	6,499,690	3.09
1913...	16,632	146,001	57,178,296	12,015,739	2,594,826	2,638,073	8,341,798	3.21

Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904....	130,214	132,297	$745,744	$5.73	79,590	80,772	$1,765,107	$22.20
1905....	56,021	56,917	273,289	4.88	212,465	215,864	5,185,784	24.41
1906....	23,281	23,653	147,547	6.34	379,828	385,905	11,851,210	31.20
1907....	25,876	26,290	163,944	6.34	489,475	497,305	13,418,982	27.42
1908....	26,734	27,161	175,365	6.56	92,202	93,677	2,886,339	31.35
1909....	11,903	12,094	97,277	8.18	176,442	179,265	5,112,045	28.97
1910....	19,384	19,688	235,040	12.12	237,233	241,029	6,549,938	27.61
1911....	16,153	16,412	157,394	9.74	148,459	150,842	4,380,334	29.50
1912....	28,821	29,284	231,255	8.02	129,325	131,401	4,770,730	36.89
1913....	.....	.....	.....	.....	120,612	122,622	5,144,634	42.65

Year.	Scrap, Iron and Steel.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1904.....	13,461	13,676	$189,506	20,905	21,247	$917,254
1905.....	23,731	24,111	370,328	37,294	37,891	1,522,434
1906.....	19,091	19,397	248,106	35,793	36,366	1,590,592
1907.....	27,652	28,094	368,842	39,746	40,382	1,774,441
1908.....	5,090	5,171	61,981	19,671	19,980	837,585
1909.....	63,504	64,523	781,426	19,210	19,518	806,862
1910.....	72,764	73,928	928,002	38,231	38,783	1,565,999
1911.....	17,272	17,549	190,285	26,730	27,159	1,202,363
1912.....	23,612	23,991	256,710	26,112	26,531	1,151,853
1913.....	44,153	44,889	510,707	28,243	28,714	1,340,184

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1904...	37,776	38,380	$808,775	2,135	2,169	$60,934	(m)10,807	10,980	$1,537,531
1905...	17,278	17,554	409,807	4,772	4,848	137,612	(m)14,641	14,875	2,072,606
1906...	4,943	5,022	137,104	10,231	10,395	256,836	(m)21,337	21,678	3,010,589
1907...	3,752	3,812	104,958	1,508	1,532	82,706	(m)19,334	19,643	3,004,178
1908...	1,719	1,752	53,128	1,110	1,127	75,920	11,212	11,391	1,437,514
1909...	1,542	1,567	36,963	(n)	(n)	(n)	19,289	19,599	2,695,630
1910...	(n)	(n)	(n)	(n)	(n)	(n)	46,578	47,323	4,075,036
1911...	(n)	(n)	(n)	(n)	(n)	(n)	29,205	29,687	2,772,614
1912...	3,780	3,841	101,544	(n)	(n)	(n)	18,702	19,002	2,941,431
1913...	10,408	10,581	116,272	(n)	(n)	(n)	17,766	18,062	2,651,722

Year.	Sheet, Plate and Taggers Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1904...	4,165	4,232	$302,500	70,652	71,782	$4,354,761	15,313	15,558	$707,779
1905...	2,236	2,272	242,955	65,740	66,792	4,090,523	17,616	17,898	800,027
1906...	3,231	3,283	325,276	56,982	57,894	3,883,225	17,799	18,084	876,270
1907...	3,749	3,809	367,140	57,773	58,697	4,462,522	17,076	17,349	851,571
1908...	2,628	2,669	377,549	58,492	59,426	3,651,576	11,208	11,387	543,170
1909...	4,711	4,787	536,841	62,593	63,598	3,782,952	10,544	10,613	531,652
1910...	6,107	6,205	461,632	67,086	68,159	4,502,862	20,374	20,700	1,024,831
1911...	2,454	2,495	275,498	14,089	14,324	1,081,864	15,483	15,980	731,291
1912...	3,300	3,353	363,141	2,053	2,087	229,891	15,069	15,311	726,205
1913...	2,929	2,978	382,566	20,680	21,024	1,478,635	16,098	16,366	802,401

Year.	Wire and Articles Made from.			Total Iron Imports. (e)	Lead in Ore and Base Bullion.		
	Long Tons.	Metric Tons.	Value.		Short Tons.	Metric Tons	Value.
1904 ...	3,956	4,019	$624,892	$21,621,970	104,127	94,464	$3,517,691
1905 ...	3,978	4,042	705,465	26,401,283	92,657	84,081	3,565,282
1906 ...	6,610	6,716	1,079,868	34,827,132	72,371	65,640	3,490,750
1907 ...	(f)	(f)	1,551,415	38,789,992	70,538	64,019	3,579,990
1908 ...	(f)	(f)	1,003,973	19,957,385	109,315	99,168	4,384,904
1909 ...	(f)	(f)	1,117,812	30,571,542	110,605	100,339	4,121,380
1910 ...	(f)	(f)	1,468,741	47,115,112	105,117	106,805	4,056,722
1911 ...	(f)	(f)	1,270,426	28,995,600	87,319	79,215	3,452,695
1912 ...	(f)	(f)	1,103,192	29,328,709	83,288	75,568	3,721,583
1913 ...	(f)	(f)	1,167,368	33,601,222	57,105	51,819	2,962,139

Year.	Lead in Pigs and Old.			Lead, Sheet, Pipe, Shot, etc.			Other Lead Mfres.	Total Lead.
	Short Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.		
1904.....	8,724	7,914	$461,316	69,581	32	$2,441	$7,755	$3,989,203
1905.....	5,720	5,812	367,106	54,779	25	2,638	4,580	3,939,606
1906.....	11,763	10,669	910,417	346,177	157	17,250	20,681	4,401,167
1907.....	9,277	8,414	846,166	734,418	333	39,210	12,736	4,426,156
1908.....	2,759	2,504	182,503	42,376	19	2,026	46,486	4,567,407
1909.....	3,576	3,244	230,347	40,434	18	2,056	33,892	4,351,727
1910.....	3,491	3,166	202,376	(f)	.....	.....	7,073	4,259,098
1911.....	2,632	2,388	190,543	(f)	.....	.....	9,834	3,642,238
1912.....	272	247	19,917	31,284	14	2,305	5,023	3,748,828
1913.....	41	38	3,678	(f)	(f)	(f)	17,138	2,982,955

Year.	White Lead.				Litharge.				Red Lead.			
	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.
1904...	587,338	266	$33,788	$0.058	44,541	20	$1,500	$0.034	836,077	379	$30,115	$0.036
1905...	597,510	271	34,722	0.058	117,757	53	4,139	0.035	704,402	320	26,553	0.038
1906...	647,636	294	41,233	0.064	87,230	40	3,737	0.043	1,093,619	497	50,741	0.046
1907...	584,309	265	37,482	0.064	90,475	41	4,386	0.048	679,171	308	35,959	0.053
1908...	540,311	245	30,451	0.056	96,184	44	3,327	0.035	645,073	292	28,155	0.034
1909...	694,599	315	39,963	0.057	90,655	32	3,740	0.041	760,179	345	30,428	0.040
1910...	686,052	311	38,919	0.057	48,693	22	2,252	0.046	822,289	373	32,750	0.039
1911...	741,071	336	46,213	0.062	24,662	11	1,196	0.048	1,163,533	528	46,170	0.040
1912. .	687,705	312	46,494	0.068	32,443	15	1,550	0.048	757,908	344	33,854	0.045
1913...	671,839	305	48,266	0.072	34,023	15	1,750	0.051	99,562	45	4,903	0.049

Year.	Orange Mineral.				Magnesite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value. per L.T.
1904.....	766,469	348	$37,178	$0.049	35,106	35,668	$286,828	$8.17
1905.....	628,003	285	31,106	0.049	66,405	67,566	638,619	9.46
1906.....	770,342	350	42,519	0.055	80,711	82,002	863,492	10.70
1907.....	615,015	279	37,793	0.061	88,400	89,814	875,359	9.90
1908.....	485,407	220	26,645	0.055	75,442	76,648	736,763	9.80
1909.....	496,231	225	27,562	0.056	102,045	103,683	985,019	9.66
1910.....	600,461	269	32,199	0.053	152,078	154,511	1,542,800	10.14
1911.....	504,734	229	28,515	0.056	120,133	122,061	1,185,867	9.85
1912.....	334,551	152	20,914	0.063	123,801	125,788	1,369,665	11.06
1913.....	330,525	150	22,205	0.067	161,012	163,696	1,757,476	10.92

Year.	Manganese Ore.				Mica.	Nickel. (h)	Nickel Ore and Matte.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.			Long Tons.	Metric Tons.	Value.
1904.....	108,519	110,255	$901,592	$8.31	$269,808	$206,021	8,549	8,685	$915,470
1905.....	257,033	261,146	1,952,407	7.60	403,755	335,211	13,451	13,666	1,626,929
1906.....	221,260	224,800	1,696,043	7.67	1,042,608	86,336	15,156	15,398	1,816,621
1907.....	209,021	211,236	1,793,143	8.59	915,259	90,153	16,888	17,158	2,153,971
1908.....	178,023	181,054	1,350,223	7.59	264,755	101,398	16,322	16,582	2,396,217
1909.....	212,765	216,180	1,405,329	6.60	493,978	104,019	18,578	18,876	2,927,975
1910.....	242,348	246,226	1,711,131	7.06	721,541	139,772	28,519	28,975	4,085,076
1911.....	176,852	179,690	1,186,791	6.71	469,089	104,160	23,993	24,378	3,918,556
1912.....	300,661	305,487	1,769,184	5.84	745,399	120,511	33,101	33,632	5,635,459
1913.....	345,060	350,811	2,029,680	5.87	981,601	(f)	37,582	38,206	6,423,423

Year.	Oil, Mineral.			Platinum, Unmanufactured.				Platinum Mfrs.
	Gal.	Value	Value per Gal.	Lb. Troy.	Kg.	Value.	Value per Lb. Troy.	
1904....	4,846,681	$277,399	$0.057	8,648	3,230	$1,812,242	$209.55	$105,636
1905....	13,725,720	672,127	0.049	8,681	3,240	1,985,107	228.67	188,158
1906....	21,045,316	1,061,076	0.050	13,928	5,198	3,601,021	258.54	187,639
1907....	20,505,197	1,037,728	0.051	7,515	2,805	2,509,926	333.99	175,651
1908....	9,289,376	393,050	0.042	4,155	1,551	1,096,615	263.92	134,119
1909....	3,862,445	198,540	0.051	9,904	3,696	2,557,574	258.30	410,997
1910....	24,323,829	1,438,609	0.059	10,009	3,736	3,320,099	331.77	1,717,584
1911....	69,019,304	2,406,581	0.035	2,868	1,070	1,278,293	445.71	3,587,998
1912....	309,766,530	6,033,231	0.019	3,692	1,378	1,716,630	464.96	2,777,653
1913....	731,360,523	12,997,011	0.018	4,282	1,600	1,978,770	462.11	3,065,489

Year.	Potassium Salts.											
	Chlorate.			Chloride.			Chromate and Bichromate.			Nitrate.		
	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.
		$	$		$	$		$	$		$	$
1904....	95,889	4,209	0.044	174,865,872	2,832,554	0.016	26,053	1,817	0.069	14,184,287	376,931	0.027
1905....	42,510	2,876	0.067	214,207,064	3,326,748	0.016	59,650	4,225	0.070	9,911,534	304,596	0.031
1906....	45,873	3,103	0.068	223,203,387	3,858,895	0.017	30,098	2,102	0.080	11,326,256	371,595	0.033
1907....	12,980	959	0.074	252,303,441	4,175,353	0.017	18,171	1,307	0.072	18,291,820	574,977	0.031
1908....	17,607	1,447	0.082	214,338,887	3,415,326	0.016	216,080	15,453	0.072	16,118,180	470,116	0.029
1909....	22,425	1,837	0.082	298,854,649	4,780,106	0.016	640,623	31,798	0.050	14,883,849	437,690	0.029
1910....	410,770	26,313	0.064	381,873,875	5,252,373	0.014	406,791	19,569	0.048	11,496,904	333,854	0.029
1911....	27,856	2,450	0.088	509,119,193	7,651,684	0.015	22,408	2,159	0 096	7,945,747	265,061	0.033
1912....	99,919	6,787	0.068	482,265,665	7,229,109	0.015	32,913	3,085	0.094	7,315,531	216,492	0.030
1913....	1,191,461	64,468	0.054	478,826,857	7,120,055	0.015	18,629	1,819	0.097	9,876,910	262,575	0.027

Year	Potassium Salts. All Other. (s)		Precious Stones.			Pyrite. (i)			
	Lb.	Value.	Uncut.	Cut, not Set.	Jewelry.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904.	74,720,241	$1,678,699	$10,316,615	$16,934,090	$803,952	413,585	420,202	$1,533,584	$3.73
1905.	82,935,632	1,891,081	10,206,350	26,699,670	801,566	515,722	520,926	1,780,800	3.47
1906.	30,302,735	763,513	11,937,542	32,201,949	988,766	597,347	606,903	2,138,746	3.58
1907.	91,299,496	2,220,685	8,740,278	23,706,975	1,069,373	256,479	666,981	2,637,455	4.01
1908.	69,382,278	1,721,626	2,367,189	11,660,442	720,502	668,115	678,804	2,624,389	3.93
1909.	100,180,417	2,445,526	9,230,287	34,340,289	1,267,457	692,385	703,498	2,428,638	3.51
1910.	116,820,873	2,777,396	9,426,647	32,424,471	1,907,148	806,590	819,495	2,773,617	3.46
1911.	155,140,643	3,909,361	9,963,393	30,224,826	1,470,167	1,001,944	1,018,025	3,788,682	3.78
1912.	131,049,932	3,185,098	9,979,582	26,218,261	989,288	964,478	979,958	3,680,738	3.98
1913.	124,519,551	3,253,245	12,630,037	27,526,937	908,723	848,674	862,819	3,611,136	4.26

Year.	Salt.				Silver.		Sodium Nitrate.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904	167,295	151,810	$515,822	$3.08	$11,865,805	$14,221,237	228,012	231,660	$9,333,613	$32.41
1905	158,449	143,783	491,079	3.10	16,472,911	19,466,224	321,231	326,371	11,206,548	34.89
1906	170,505	154,648	502,583	2.95	20,402,738	23,825,103	372,222	378,178	14,115,206	37.92
1907	153,435	139,166	452,227	2.95	17,652,679	28,259,681	364,610	370,444	14,844,675	40.71
1908	156,608	142,043	440,484	2.81	14,169,524	28,054,606	310,713	315,684	11,385,393	36.68
1909	158,487	143,777	447,983	2.83	15,728,756	30,458,946	428,429	435,569	13,608,195	31.43
1910	142,549	129,320	388,015	2.72	15,913,668	29,964,500	529,172	605,938	16,601,328	31.37
1911	137,759	124,974	378,083	2.74	16,351,154	27,395,417	544,878	553,623	16,814,256	30.86
1912	136,391	123,733	361,664	2.65	24,053,983	24,347,103	486,352	494,158	16,554,104	34.04
1913	150,551	153,060	416,375	2.77	21,694,293	19,574,223	625,862	636,293	21,630,811	34.56

Year.	Sodium Hydroxide (Caustic).			Soda Ash and Carbonate.			All other Sodium Salts.	
	Lb.	Value.	Value. per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.
1904	2,570,984	$64,405	$0.025	23,631,832	$205,496	$0.009	10,399,711	$281,527
1905	2,245,789	56,515	0.025	15,754,979	146,812	0.009	11,257,629	247,413
1906	1,209,053	35,262	0.022	6,800,288	71,013	0.010	.....	.....
1907	1,297,070	37,894	0.029	6,198,136	66,521	0.011	8,481,979	258,262
1908	874,813	26,079	0.029	3,515,933	38,372	0.011	.....	296,777
1909	942,982	29,771	0.032	153,928	3,543	0.023	13,805,869	350,396
1910	2,973,522	70,901	0.027	314,396	4,269	0.014	35,895,668	406,643
1911	990,562	34,281	0.035	3,214,129	36,252	0.011	22,202,439	303,934
1912	884,204	29,461	0.033	3,393,354	39,912	0.012	7,332,392	232,808
1913	696,158	25,888	0.037	2,962,180	35,872	0.012	7,518,125	263,162

Year.	Sulphur.									
	Crude.				Flowers.			Refined.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1904	128,885	130,947	$2,463,779	$19.12	1,332	1,353	$39,133	204	207	$9,776
1905	83,201	84,532	1,522,005	18.29	572	581	16,037	778	709	19,960
1906	72,404	73,562	1,282,873	17.72	1,100	1,118	29,565	709	720	17,928
1907	20,399	20,725	355,944	17.45	1,458	1,481	41,216	606	616	14,589
1908	20,118	20,441	318,577	15.83	793	804	22,562	692	700	17,227
1909	26,914	27,346	458,954	17.05	770	782	23,084	966	982	26,021
1910	28,647	29,105	495,988	17.31	915	930	30,180	990	1,004	25,869
1911	24,250	24,639	436,725	18.01	3,891	3,953	83,491	986	1,002	24,906
1912	26,885	27,317	494,778	18.40	1,310	1,331	39,126	1,665	1,692	40,933
1913	14,636	14,880	278,056	19.00	5,899	5,997	115,574	1,233	1,254	29,091

Year.	Talc.				Tin.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1904	3,268	2,964	$36,370	$11.13	83,168,657	37,718	$22,356,896	$0.270
1905	4,000	3,630	48,225	12.06	89,227,698	40,507	26,316,023	0.294
1906	5,643	5,118	67,818	12.02	101,027,188	45,816	37,446,508	0.371
1907	10,060	10,221	126,391	12.56	82,548,838	37,436	32,075,091	0.389
1908	7,429	6,738	97,296	13.08	82,503,190	37,433	23,932,560	0.290
1909	8,377	7,599	102,964	12.29	95,350,020	43,250	27,559,937	0.289
1910	8,378	7,560	106,451	12.72	105,137,740	47,703	33,921,449	0.322
1911	7,113	6,453	88,050	12.38	106,936,872	48,506	43,390,639	0.406
1912	10,817	9,813	121,541	11.24	116,003,385	52,619	50,371,102	0.434
1913	14,004	12,702	143,500	10.25	104,282,230	47,315	46,900,314	0.450

Year.	Zinc. Blocks, Pigs and Old. Lb.	Metric Tons.	Value.	Value per Lb.	Oxide. (j) Lb.	Value.	Sulphide. Lb.	Value.
1904	933,474	423	$44,455	0.048	2,809,905	$165,110	1,228,875	$
1905	1,042,081	473	51,052	0.048	3,779,311	196,220	1,235,360	
1906	4,407,481	1,999	253,310	0.057	4,494,014	288,065	1,286,469	
1907	3,555,860	1,613	210,322	0.059	5,311,318	323,551	1,570,073	
1908	1,762,627	799	85,885	0.049	4,635,101	262,876	1,048,109	
1909	19,340,029	8,772	826,588	0.043	6,654,352	397,084	1,263,316	
1910	6,904,389	3,133	299,689	0.042	6,470,097	391,670	3,726,135	
1911	3,275,340	1,486	170,634	0.052	5,561,016	357,466	6,355,312	166
1912	22,229,831	10,083	1,280,426	0.058	5,875,057	386,153	5,904,475	15
1913	12,199,267	5,535	660,706	0.054	6,865,094	433,886	5,066,535	15

(a) From Summary of Commerce and Finance of the United States. (b) Includes arsenic sulphide. 400 lb. (e) Not including iron ore. (f) Not reported. (g) Includes pig and old. (h) Includes nickel in which nickel is the principal constituent and manufactures of nickel. (i) Containing more than 25 per (j) Includes white pigments containing zinc but not lead, dry and in oil. (m) Includes bars of steel not elsewhere specified. The high value is due to the value of "high-speed" steel. (n) Crude. (o) alloys in which aluminum is chief component. (p) Crude and refined. (q) Also included in all other ash only. (r) Antimony contents of ores and regulus and metal. (s) Not kaimit.

EXPORTS OF DOMESTIC PRODUCTS. (a)

Year.	Aluminium and Mfrs. of.	Asbestos and Mfrs of.	Cement. Bbl.(i)	Metric Tons.	Value.	Valu
1904	$166,876	$223,096	774,940	140,898	$1,104,086	
1905	290,777	.....	1,016,236	185,345	1,387,706	
1906	364,251	259,760	583,299	105,811	944,886	
1907	304,938	200,371	900,550	163,360	1,450,841	
1908	330,092	296,890	846,785	153,638	1,249,229	
1909	567,375	322,523	1,056,922	191,764	1,417,534	
1910	949,215	348,716	2,475,957	449,314	3,477,981	
1911	1,158,603	448,395	3,135,409	568,886	4,632,215	
1912	1,347,621	625,328	4,215,532	764,861	6,160,341	
1913	966,094	754,102	2,964,358	537,996	4,270,666	

Year.	Coal. Anthracite. Long Tons.	Metric Tons.	Value.	Value per L. T.	Bituminous. Long Tons.	Metric Tons.	Value.	Value per L.T.	Coke. Long Tons.	
1904	2,228,392	2,264,046	$11,077,570	$4.97	6,345,126	6,446,648	$17,160,538	$2.74	523,090	$2
1905	2,229,983	2,265,663	11,104,654	4.98	6,959,265	7,070,613	17,867,964	2.56	599,054	2
1906	2,216,969	2,252,441	10,896,200	4.91	7,704,850	7,828,128	(k)19,787,459	2.57	765,190	2
1907	2,698,072	2,741,241	13,217,985	4.90	(m)10,454,677	10,621,950	(m)26,982,111	2.54	874,689	3
1908	2,752,358	2,796,394	13,524,595	4.92	(m) 9,100,819	9,246,431	(m)23,361,914	2.53	620,923	2
1909	2,842,714	2,888,340	14,141,468	4.97	(m) 9,693,843	9,849,429	(m)24,300,050	2.51	895,461	3
1910	3,021,627	3,070,124	14,785,387	4.89	(m)10,784,239	10,957,326	(m)26,685,405	2.47	879,073	3
1911	3,553,999	3,611,041	18,093,285	5.09	(m)13,878,754	14,101,508	(m)34,499,989	2.49	914,042	3
1912	3,688,789	3,747,964	19,425,263	5.27	(m)14,459,978	14,692,061	(m)36,817,633	2.55	814,800	3
1913	4,154,386	4,223,626	21,759,850	5.24	(m)17,986,757	18,286,535	(m)45,449,664	2.53	881,603	3

Year.	Copper. In Ore and Matte (b). Long Tons.	Metric Tons.	Value.	Value per L. T.	Ingots, Bars, Plates and Old. Lb.	Metric Tons.	Value.	Value per Lb.	Mfrs. Value.	Total except
1904	18,927	19,230	$1,202,537	$63.54	554,550,030	251,497	$71,488,116	$0.129	$3,328,818	$74,816
1905	37,688	38,291	1,531,429	40.63	534,907,619	242,699	80,693,232	0.151	4,184,070	84,890
1906	47,619	48,380	1,760,140	36.96	454,752,018	206,239	84,728,400	0.186	4,284,611	89,013
1907	99,141	100,727	2,452,562	24.74	508,929,401	230,799	94,912,185	0.186	5,888,170	100,800
1908	63,149	64,158	1,254,172	19.87	661,876,127	300,302	87,393,200	0.132	3,162,303	90,555
1909	59,880	60,841	1,335,316	22.29	682,846,726	309,734	89,367,455	0.131	3,217,185	92,584
1910	43,784	44,585	1,049,086	23.96	695,107,043	315,384	88,949,799	0.128	5,132,287	94,082
1911	57,915	58,844	2,352,080	40.61	786,553,208	356,778	98,168,182	0.122	5,159,664	103,327
1912	66,171	67,233	3,203,220	48.41	775,000,658	351,538	123,007,884	0.159	3,762,283	126,770
1913	65,684	66,779	2,973,997	45.28	926,441,142	420,345	143,353,703	0.155	1,555,414	144,909

Year.	Gold.		Iron.							
			Ore.				Pig.			
	In Coin and Bullion. (c)	In Ore. (d)	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904.....	$120,226,424	$985,403	213,865	217,287	$458,823	$2.14	49,025	49,809	$764,543	$15.60
1905.....	46,099,580	694,887	208,017	211,345	530,457	2.55	49,221	50,009	762,899	15.50
1906.....	46,068,451	640,707	265,240	269,484	771,831	2.91	83,317	84,650	1,506,774	18.08
1907.....	54,869,688	345,993	278,208	282,659	763,422	2.74	73,703	74,879	1,508,938	20.43
1908.....	80,778,091	437,365	309,099	314,043	1,012,924	3.29	46,696	47,441	789,318	16.92
1909.....	132,340,610	540,211	455,934	463,251	1,365,325	2.99	61,989	62,994	1,030,267	16.66
1910.....	58,305,510	469,312	644,875	655,193	2,074,164	3.22	127,385	129,423	2,113,036	16.51
1911.....	36,683,309	499,265	768,386	780,719	2,653,448	3.45	120,799	122,738	1,874,401	15.52
1912.....	43,921,951	470,333	1,195,742	1,214,934	3,537,289	2.96	272,676	277,052	3,832,765	14.06
1913.....	76,096,519	608,032	1,042,151	1,059,520	3,513,419	3.37	277,648	282,275	4,026,206	14.50

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.			Billets, Ingots and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904.....	29,582	30,055	$1,133,128	$34.93	3,435	3,489	$162,039	314,324	319,353	$6,150,035	$19.56
1905.....	32,025	32,537	1,255,418	39.20	4,426	4,497	182,431	237,738	241,542	4,701,909	19.79
1906.....	56,024	56,920	2,575,905	45.98	5,405	5,491	242,776	192,616	195,698	4,094,659	21.26
1907.....	24,190	24,577	1,092,631	45.17	8,587	8,724	395,758	79,991	81,271	2,013,319	25.17
1908.....	8,224	8,355	362,909	44.12	4,334	4,402	223,073	112,177	113,390	2,674,524	23.84
1909.....	13,536	13,755	538,436	39.77	3,856	3,918	200,379	104,862	106,545	2,401,091	22.90
1910.....	18,045	18,234	726,300	40.25	(n)	(n)	(n)	58,230	59,162	1,274,732	21.89
1911.....	17,683	17,967	653,320	36.94	3,731	3,791	163,853	234,267	238,027	5,150,518	21.99
1912.....	21,926	22,278	841,824	38.39	12,557	12,759	539,354	294,818	300,566	6,615,131	22.44
1913.....	16,615	16,892	768,501	46.25	16,814	17,094	767,631	91,847	93,378	2,200,248	23.96

Year.	Iron, Nails and Spikes, Cut.				Iron, Nails and Spikes, All Other.				Iron, Plates and Sheets.		
	Lb.	Metric Tons.	Value	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Met. Tons.	Value.
1904	20,772,049	9,422	$416,389	$0.020	80,279,746	36,403	$1,949,908	$0.024	4,728	4,804	$247,694
1905	17,674,099	8,019	352,405	0.020	89,976,088	40,506	2,118,836	0.024	8,004	8,132	460,995
1906	16,951,893	7,688	340,526	0.020	116,310,428	52,747	2,731,021	0.024	17,054	17,327	1,139,526
1907	15,521,208	7,042	354,802	0.023	111,670,147	50,642	3,014,863	0.027	40,651	41,301	2,902,025
1908	15,721,898	7,133	364,202	0.023	71,427,124	32,407	1,813,784	0.025	44,100	44,805	2,985,538
1909	22,256,458	10,095	456,635	0.021	85,387,006	38,731	1,993,142	0.023	75,305	76,513	4,706,592
1910	18,208,116	8,261	361,838	0.020	118,881,375	53,939	2,693,753	0.023	102,534	104,175	6,412,458
1911	25,585,379	11,605	470,515	0.018	148,875,384	67,529	3,279,105	0.022	134,497	137,113	8,353,089
1912	20,856,790	9,461	359,962	0.017	186,646,479	84,733	3,976,571	0.021	194,165	197,281	11,844,767
1913	8,488,503	3,851	165,068	0.019	132,015,432	59,898	3,031,967	0.023	98,978	100,628	6,568,413

Year.	Steel, Sheets and Plates.			Iron Rails.				Steel Rails.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904 ..	50,477	51,278	$2,064,241	1,405	1,427	$23,870	$17.00	414,845	421,482	$10,661,222	$25.72
1905 ..	67,093	68,166	2,889,084	*Nil.*	.....	.....	.....	295,023	299,473	7,310,029	24.78
1906 ..	93,601	95,099	4,081,915	*Nil.*	.....	.....	.....	328,036	333,285	8,903,411	27.14
1907 ..	82,045	83,358	4,262,582	*Nil.*	.....	.....	.....	338,906	344,328	10,411,072	30.72
1908 ..	60,893	61,865	3,422,031	*Nil.*	.....	.....	.....	196,510	199,654	6,021,549	30.62
1909 ..	104,742	106,423	4,627,614	*Nil.*	.....	.....	.....	299,540	304,533	8,519,793	28.44
1910 ..	171,982	174,734	7,514,832	*Nil.*	.....	.....	.....	353,180	358,831	10,162,522	28.77
1911 .	237,428	241,239	9,800,215	*Nil.*	.....	.....	.....	420,874	427,629	12,229,045	29.05
1912 .	352,802	358,464	14,508,622	*Nil.*	.....	.....	.....	446,473	453,639	13,053,774	29.24
1913 ..	364,269	370,340	14,472,711	*Nil.*	.....	.....	.....	460,553	468,229	13,979,549	30.35

Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric. Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1904....	130,214	132,297	$745,744	$5.73	79,590	80,772	$1,765,107	$22.20
1905....	56,021	56,917	273,289	4.88	212,465	215,864	5,185,784	24.41
1906....	23,281	23,653	147,547	6.34	379,828	385,905	11,851,210	31.20
1907....	25,876	26,290	163,944	6.34	489,475	497,305	13,418,982	27.42
1908....	26,734	27,161	175,365	6.56	92,202	93,677	2,886,339	31.35
1909....	11,903	12,094	97,277	8.18	176,442	179,265	5,112,045	28.97
1910....	19,384	19,688	235,040	12.12	237,233	241,029	6,549,938	27.61
1911....	16,153	16,412	157,394	9.74	148,459	150,842	4,380,334	29.50
1912....	28,821	29,284	231,255	8.02	129,325	131,401	4,770,730	36.89
1913....	.....	.....	.....	.....	120,612	122,622	5,144,634	42.65

Year.	Scrap, Iron and Steel.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1904.....	13,461	13,676	$189,506	20,905	21,247	$917,254
1905.....	23,731	24,111	370,328	37,294	37,891	1,522,434
1906.....	19,091	19,397	248,106	35,793	36,366	1,590,592
1907.....	27,652	28,094	368,842	39,746	40,382	1,774,441
1908.....	5,090	5,171	61,981	19,671	19,980	837,585
1909.....	63,504	64,523	781,426	19,210	19,518	806,862
1910.....	72,764	73,928	928,002	38,231	38,783	1,565,999
1911.....	17,272	17,549	190,285	26,730	27,159	1,202,363
1912.....	23,612	23,991	256,710	26,112	26,531	1,151,853
1913.....	44,153	44,889	510,707	28,243	28,714	1,340,184

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1904...	37,776	38,380	$808,775	2,135	2,169	$60,934	(m)10,807	10,980	$1,537,531
1905...	17,278	17,554	409,807	4,772	4,848	137,612	(m)14,641	14,875	2,072,606
1906...	4,943	5,022	137,104	10,231	10,395	256,836	(m)21,337	21,678	3,010,589
1907...	3,752	3,812	104,958	1,508	1,532	82,706	(m)19,334	19,643	3,004,178
1908...	1,719	1,752	53,128	1,110	1,127	75,920	11,212	11,391	1,437,514
1909...	1,542	1,567	36,963	(n)	(n)	(n)	19,289	19,599	2,695,630
1910...	(n)	(n)	(n)	(n)	(n)	(n)	46,578	47,323	4,075,036
1911...	(n)	(n)	(n)	(n)	(n)	(n)	29,205	29,687	2,772,614
1912...	3,780	3,841	101,544	(n)	(n)	(n)	18,702	19,002	2,941,431
1913...	10,408	10,581	116,272	(n)	(n)	(n)	17,766	18,062	2,651,722

Year.	Sheet, Plate and Taggers Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1904...	4,165	4,232	$302,500	70,652	71,782	$4,354,761	15,313	15,558	$707,779
1905...	2,236	2,272	242,955	65,740	66,792	4,090,523	17,616	17,898	800,027
1906...	3,231	3,283	325,276	56,982	57,894	3,883,225	17,799	18,084	876,270
1907...	3,749	3,809	367,140	57,773	58,697	4,462,522	17,076	17,349	851,571
1908...	2,628	2,669	377,549	58,492	59,426	3,651,576	11,208	11,387	543,170
1909...	4,711	4,787	536,841	62,593	63,598	3,782,952	10,544	10,613	531,652
1910...	6,107	6,205	461,632	67,086	68,159	4,502,862	20,374	20,700	1,024,831
1911...	2,454	2,495	275,498	14,089	14,324	1,081,864	15,483	15,980	731,291
1912...	3,300	3,353	363,141	2,053	2,087	229,891	15,069	15,311	726,205
1913...	2,929	2,978	382,566	20,680	21,024	1,478,635	16,098	16,366	802,401

Year.	Wire and Articles Made from.			Total Iron Imports. (c)	Lead in Ore and Base Bullion.		
	Long Tons.	Metric Tons.	Value.		Short Tons.	Metric Tons	Value.
1904 ...	3,956	4,019	$624,892	$21,621,970	104,127	94,464	$3,517,691
1905 ...	3,978	4,042	705,465	26,401,283	92,657	84,081	3,565,282
1906 ...	6,610	6,716	1.079,868	34,827,132	72,371	65,640	3,490,750
1907 ...	(S)	(S)	1,551,415	38,789,992	70,538	64,019	3,579,990
1908 ...	(S)	(S)	1,003,973	19,957,385	109,315	99,168	4,384,904
1909 ...	(S)	(S)	1,117,812	30,571,542	110,605	100,339	4,121,380
1910 ...	(S)	(S)	1,468,741	47,115,112	105,117	106,805	4,056,722
1911 ...	(S)	(S)	1,270,426	28,995,600	87,319	79,215	3,452,695
1912 ...	(S)	(S)	1,103,192	29,328,709	83,288	75,558	3,721,583
1913 ...	(S)	(S)	1,167,368	33,601,222	57,105	51,819	2,962,139

Year.	Lead in Pigs and Old.			Lead, Sheet, Pipe, Shot, etc.			Other Lead Mfres.	Total Lead.
	Short Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.		
1904.....	8,724	7,914	$461,316	69,581	32	$2,441	$7,755	$3,989,203
1905.....	5,720	5,812	367,106	54,779	25	2,638	4,580	3,939,606
1906.....	11,763	10,669	910,417	346,177	157	17,250	20,681	4,401,167
1907.....	9,277	8,414	846,166	734,418	333	39,210	12,736	4,426,156
1908.....	2,759	2,504	182,503	42,376	19	2,026	46,486	4,567,407
1909.....	3,576	3,244	230,347	40,434	18	2,056	33,892	4,351,727
1910.....	3,491	3,166	202,376	(S)	.....	.....	7,073	4,259,098
1911.....	2,632	2,388	190,543	(S)	.....	.....	9,834	3,642,238
1912.....	272	247	19,917	31,284	14	2,305	5,023	3,748,828
1913.....	41	38	3,678	(S)	(S)	(S)	17,138	2,982,955

Year.	White Lead.				Litharge.				Red Lead.			
	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.
1904...	587,338	266	$33,788	$0.058	44,541	20	$1,500	$0.034	836,077	379	$30,115	$0.036
1905...	597,510	271	34,722	0.058	117,757	53	4,139	0.035	704,402	320	26,553	0.038
1906...	647,636	294	41,233	0.064	87,230	40	3,737	0.043	1,093,619	497	50,741	0.046
1907...	584,309	265	37,482	0.064	90,475	41	4,386	0.048	679,171	308	35,959	0.053
1908...	540,311	245	30,451	0.056	96,184	44	3,327	0.035	645,073	292	28,155	0.034
1909...	694,599	315	39,963	0.057	90,655	32	3,740	0.041	760,179	345	30,428	0.040
1910...	686,052	311	38,919	0.057	48,693	22	2,252	0.046	822,289	373	32,750	0.039
1911...	741,071	336	46,213	0.062	24,662	11	1,196	0.048	1,163,533	528	46,170	0.040
1912...	687,705	312	46,494	0.068	32,443	15	1,550	0.048	757,908	344	33,854	0.045
1913...	671,839	305	48,266	0.072	34,023	15	1,750	0.051	99,562	45	4,903	0.049

Year.	Orange Mineral.				Magnesite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value. per L.T.
1904.....	766,469	348	$37,178	$0.049	35,106	35,668	$286,828	$8.17
1905.....	628,003	285	31,106	0.049	66,405	67,566	638,619	9.46
1906.....	770,342	350	42,519	0.055	80,711	82,002	863,492	10.70
1907.....	615,015	279	37,793	0.061	88,400	89,814	875,359	9.90
1908.....	485,407	220	26,645	0.055	75,442	76,648	736,763	9.80
1909.....	496,231	225	27,562	0.056	102.045	103,683	985,019	9.66
1910.....	600,461	269	32,199	0.053	152,078	154,511	1,542,800	10.14
1911.....	504,734	229	28,515	0.056	120,133	122,061	1,185,867	9.85
1912.....	334,551	152	20,914	0.063	123,801	125,788	1,369,685	11.06
1913.....	330,525	150	22,205	0.067	161,012	163,696	1,757,476	10.92

Year.	Chemicals. (*Continued.*)											
	Nitrate of Sodium.			Caustic Soda.			Soda Ash and Carbonate.			Sodium Salts, All Other.		
	Long Tons.	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1904..	6,076	6,173	$279,864	1,115,600	506,036	$23,608	40,351	18,303	$593	1,778,616	806,780	$25,312
1905..	8,991	9,135	420,613	1,087,772	493,848	22,728	32,221	14,628	473	16,748	7,604	177
1906..	6,660	6,767	324,915	(*l*)	.....	.....	2,486	1,128	41	1,032,372	468,180	21,624
1907..	7,159	7,274	370,048	(*l*)	.....	.....	3,100	1,406	53	742,201	336,662	16,099
1908..	9,955	10,113	514,799	(*l*)	.....	.....	4,645	2,104	77	834,207	378,726	18,255
1909..	8,233	8,365	377,571	(*l*)	.....	.....	(*l*)	.....	....	1,053,410	477,816	21,777
1910..	5,784	5,878	250,550	(*l*)	.....	.....	(*l*)	.....	....	333,427	151,282	11,767
1911..	6,787	6,896	269,274	(*l*)	.....	.....	(*l*)	.....	....	611,922	277,566	14,479
1912..	8,853	8,995	440,200	(*l*)	.....	.....	(*l*)	.....	....	431,407	195,685	9,416
1913..	5,560	5,653	295,111	(*l*)	.....	.....	(*l*)	.....	....	534,470	242,496	12,672

Year.	Coal, Bituminous.			Copper.						Graphite.	
				Ore and Matte.			Pigs, Bars, Ingots, Old and All Unmanufactured.				
	Long. Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.	Long Tons.	Value.
1904....	7,250	7,366	$21,910	*Nil.*	....	.....	1,088,672	494	$140,695	8	$455
1905....	3,945	4,008	10,974	*Nil.*	....	.....	1,718,584	780	272,945	5	91
1906....	2,541	2,582	13,062	71	72	$ 29,791	1,567,782	711	309,605	3	362
1907....	1,947	1,978	12,199	....	....	.....	995,555	451	199,828	1	41
1908....	4,759	4,832	16,313	2	2	50	718,541	326	93,148	....	.....
1909....	3,128	3,178	8,532	434	441	5,600	1,058,528	480	135,952	16	976
1910....	3,734	3,894	13,761	*Nil.*	....	.....	55,857	25	6,443	34	3,192
1911....	3,718	3,778	10,296	*Nil.*	....	.....	200	0.1	52	*Nil.*	.....
1912....	982	998	6,574	*Nil.*	....	.....	1,020	0.5	132	*Nil.*	.....
1913....	1,177	1,197	6,652	*Nil.*	....	.....	557	0.3	135	1	44

Year.	Iron and Steel.											
	Pig Iron.			Scrap.			Bar Iron.			Rails.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value
1904.....	1,646	1,672	$ 25,910	190	193	$ 2,367	7	7	$ 765	96	98	$2,305
1905.....	1,010	1,026	29,047	4,270	4,338	80,623	22	22	2,556	31	31	1,132
1906.....	6,750	6,858	236,957	5,111	5,193	101,886	61	62	7,207	*Nil.*	....	.....
1907.....	2,921	2,968	86,420	157	160	3,378	38	39	3,959	*Nil.*	....	.....
1908.....	1,827	1,855	52,079	288	293	3,597	26	26	1,271	*Nil.*	....	.....
1909.....	720	732	25,936	....	....	.....	20	20	1,500	*Nil.*	....	.....
1910.....	579	588	20,706	....	....	.....	9	9	356	*Nil.*	....	.....
1911.....	1,837	1,866	73,987	100	102	1,373	12	12	635	*Nil.*	....	.....
1912.....	5,087	5,169	130.107	198	201	3,788	25	25	1,176	*Nil.*	....	.....
1913.....	765	778	29,252	70	71	771	67	68	6099	*Nil.*	....	.....

Year.	Iron and Steel. (*Continued.*)									Lead and Mfrs.
	Steel, Ingots, Blooms, Etc.			Sheets, Plates, Rods, Wire.			Tin and Terne Plates, Taggers Tin.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	
1904.....	40	41	$ 6,208	108	110	$6,482	81	82	$5,306	$2,880,907
1905.....	86	87	15,570	161	164	8,019	26	26	3,014	2,441,166
1906.....	196	199	14,104	318	323	27,631	0.4	0.4	28	2,307,345
1907.....	292	297	25,974	14	14	1,220	42.2	42.9	1,813	2,416,082
1908.....	33	34	9,822	66	69	3,441	4.7	4.7	351	3,101,953
1909.....	60	61	10,389	42	43	2,630	14	14	6,273	3,139,908
1910.....	121	123	24,867	96	98	6,122	.....	.....	.....	2,511,850
1911.....	108	110	19,721	.....	.....	34,177	.....	.....	.....	4,067,574
1912.....	470	478	57,743	58	59	6,786	175	178	15,886	2,704,062
1913.....	*Nil.*	.....	.....	*Nil.*	.....	.....	1	1	250	2,107,796

Year.	Salt.			Sulphur—Crude.			Tin in Blocks, Pig and Granulated.		
	Lb.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1903.....	7,804,215	3,585	$26,636	967	982	$22,658	512	520	$317,805
1904.....	2,089,234	948	2,814	2,493	2,533	58,887	519	527	322,234
1905.....	611,912	278	893	1,713	1,741	36,858	557	567	375,763
1906.....	1,462,413	663	1,129	403	409	8,475	807	820	650,411
1907.....	1,166,049	529	1,686	301	306	5,759	562	571	492,415
1908.....	2,525,945	1,146	9,352	380	386	8,500	244	248	156,761
1909.....	1,617,705	734	1,700	16	16	284	441	448	294,649
1910.....	2,124,983	964	2,173	5	5	145	620	630	467,526
1911.....	449,025	204	646	*Nil.*	.....	.....	1,010	1,027	958,481
1912.....	73,551	33	105	1,015	1,031	20,314	588	597	591,729
1913.....	1,959,031	889	3,266	25	25	555	1,102	1,120	1,133,560

* For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.

(*a*) From Summary of Commerce and Finance of the United States. (*c*) Total exports of coin and bullion; that is, includes both foreign and domestic. (*d*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte, which is classified as copper ore, and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin. (*e*) Includes nickel oxide and nickel matte. (*f*) Includes chlorate, chloride, nitrate and all other salts of potassium. (*g*) Reported in barrels, but calculated to gallons, on a basis of 42 gallons to the barrel. (*i*) Barrel of 400 lb. (*l*) Included in all other salts of soda (*m*) Does not include coal used for fuel on vessels for foreign trade. (*n*) Included in other manufactures. (*o*) Antimony contents of regulus, etc.

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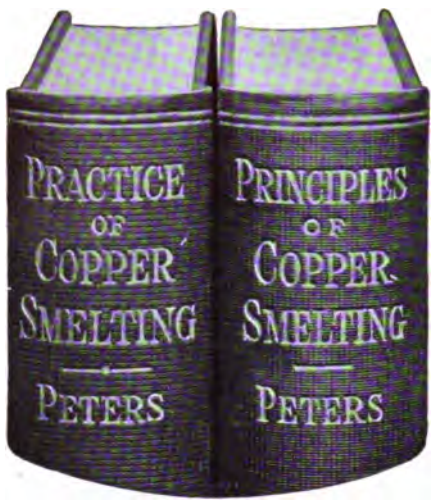

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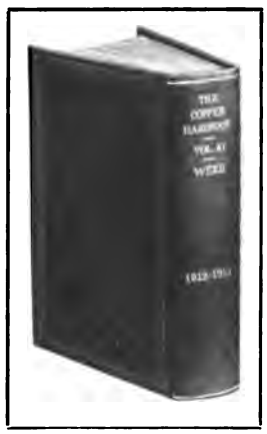

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